CONSCIOUSNESS IN RELATION TO LEARNING

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I. INTRODUCTION

The question of the relation of consciousness to learning, in the case of man, was suggested by the disagreement among psychologists as to the value of "ability to learn" as a criterion of consciousness in animals. From a purely metaphysical standpoint, those who accept the doctrine of psychophysical parallelism would admit consciousness of some sort as an attendant of the activities of all animals. Those who attack the problem from a purely empirical standpoint[1]

[1]Bethe, A.: Die anatomischen Elemente des Nervensystems, und ihre physiologische Bedeutung, *Biol. Cent.* 1898, XVIII. pp. 863 ff.
Nuel, J. P.: La psychologie comparée, est-elle légitime? *Arch. de psy.*, 1904. V. p. 320.
Ziegler, H. E.: Theoretisches zur Tierpsychologie und vergleichenden Neurophysiologie, *Biol. Cent.*, 1900, XX. p. 1.

either attempt a complete explanation of animal behavior from the physiological side without the assumption of mental qualities, or else they argue that consciousness is present only when the animal is able to profit from experience, or to profit from it rapidly enough to argue the presence of a psychic resultant of former experience.[1] Still others assume that consciousness may be present in all animal forms; but the power of associative memory is a measure of its grade, or a proof of its existence.[2] Those[3] who deny the possibility of a comparative psychology are met by the answer that the ascription of consciousness even to human beings rests upon inference and assumption, no mental states being capable of proof but our own.[4] Before considering the question of the possibility of learning without consciousness, and the relation of learning to consciousness,—which are the main themes of this study,—we shall consider briefly a few definitions of the term "consciousness," and the related terms "unconsciousness," and "subconsciousness."

II. The Concepts of Consciousness, Unconsciousness and Subconsciousness

Practically all admit that "consciousness," being an ultimate, is incapable of definition; yet it has been variously described and explained.[5] For Descartes it was equivalent to self-consciousness; Wolff was the first to give it the meaning of "ultimate property of the soul;" while others consider self-consciousness to be only a particular form of consciousness. For Lipps it is identical with the ego.[6] Usually it is broadly an equivalent for awareness or experience, and an opposite to the unconsciousness of coma, fainting, dreamless sleep, etc. Some writers make it synonymous with attention, or a general term for that experience of which attention

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[1]Loeb, J.: Comparative Physiology of the Brain and Comparative Psychology, New York, 1903. p. 12; p. 118.
Washburn, M. F.: The Animal Mind. New York, 1908. p. 33.
Romanes, G. J.: Animal Intelligence, New York, 1883. p. 4.

[2]Wundt, W.: Grundzüge der physiologischen Psychologie. (Fifth Edition.) Leipzig, 1902. III. pp. 324 ff.
Romanes, G. J.: *Op. cit.*, p. 4.

[3]Ziegler: *Op. cit.*, p. 2.

Nuel: *Op. cit.*, p. 343.

[4]Yerkes, R. M.: Objective Nomenclature, Comparative Psychology and Animal Behavior. *Jour. Comp. Neurol. and Psy.* 1906. XVI. p. 383.
Forel, A.: Ants and some other Insects. (Trans.) Chicago, 1904. p. 2.

[5]See Horwicz, A.: Psychologische Analysen, Halle, 1872-1875, for review.

[6]Lipps, T.: Leitfaden der Psychologie, Leipzig, 1909. p. 6.

is only a high degree, or with selective consciousness. Defined as "meaning" it is almost equivalent with apperception. Memory and consciousness are sometimes identified, but on the other hand, memory and unconsciousness are also identified, memory being regarded as a function of all matter, and perfect memory a characteristic of automatized acts unconsciously performed. Consciousness is frequently an equal term with "experience" and "psychic." It describes the "sum-total of our mental experience."[1] It is the interconnection of our psychic processes,[2] or a series of ideas connected with each other.[3] It is "co-ordinated psychic activity,"[4] synthesis, change, or an "orderly succession of changes." It is characterized by the pursuance of future ends, and is a synthetic unity.[5]

Consciousness is supposed to accompany only afferent impulses sent in from a moving organ,[6] or "neural processes of peculiar organization," or complex constellations of neurones.[7] It is supposed to arise "only when the motor cells are ready to discharge toward the periphery,"[8] when the sensory impression is being followed by the motor reaction;[9] "it involves not only the sensory side, but the motor discharge."[10] "It varies with the novelty of the neural processes concerned, and accompanies new connections;"[11] it "attends new complex functions."[12]

Since any definition of consciousness touches either directly or indirectly upon the disputed question of "uncon-

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[1]Wundt: Grundzüge, III, p. 321.

[2]Wundt: *Ibid.*
Titchener, E. B.: An Outline of Psychology. New York, 1908. p. 13.

[3]Calkins, M. W.: An Introduction to Psychology, New York, 1901, p. 150.

[4]Marshall, H. R.: Instinct and Reason, New York, 1898, p. 43.

[5]James, W.: Principles of Psychology, New York, 1890, I, p. 8; p. 139.
Morgan, C. L.: Introduction to Comparative Psychology, New York, 1906. (Second Edition.) p. 154.

[6]Morgan, C. L.: Animal Behaviour, London, 1900. p. 45.

[7]Sidis, B. and Goodhart, S. P.: Multiple Personality, New York, 1905. pp. 3 ff.

[8]Kirkpatrick, E. A.: The Part Played by Consciousness in Mental Operations. *Jour. of Phil., Psy. & Sci. Methods*, 1908. V. pp. 421-429.
Breese, B. B.: On Inhibition. *Psy. Rev. Mono. Supp.*, 1899, Vol. 3, No. 1, pp. 1-65.

[9]Maudsley, H.: The Physical Basis of Consciousness, *Jour. of Mental Science*, L, 1909. p. 12.

[10]Münsterberg, H.: Grundzüge der Psychologie, Leipzig, 1900. I. 531. ff.

[11]McDougall, W.: A Contribution towards an Improvement in Psychological Method, *Mind*, 1898. N. S., VII, p. 366.

[12]Royce, J.: Outlines of Psychology, New York, 1903. pp. 81-2.

scious'' or ''subconscious'' mental processes, a brief discussion of the two terms is expedient.

UNCONSCIOUSNESS

''Unconsciousness'' is a negative term denoting the opposite of consciousness. It is employed in describing states like fainting, epilepsy, or dreamless sleep where every mental quality is wanting. It is also applied to psychophysical processes which lack their normal conscious accompaniment, as pain or deep emotion temporarily forgotten during great excitement, and to perceptual processes such as the unconscious inference of depth from the fusion of the two retinal images, and the perception of a clang of definite quality from the fusion of partial tones which analysis alone discloses. Automatic acts are ''unconscious.'' The word is also loosely used for ''unreflective,'' ''unintentional,'' or ''inattentive.'' ''Unconscious mental process'' may have various meanings. It may indicate the physiological process correlated with a conscious process, or a physiological process with no psychic accompaniment, but determining consciousness later, or a neural process with psychic accompaniment of which for some reason the individual possesses no awareness. These uses will be discussed later. Whatever the metaphysical implications, the term when carefully used is a limiting concept opposed in its significance to ''consciousness.''

SUBCONSCIOUSNESS

''Subconscious'' is more ambiguous in meaning than either of the two preceding terms, and though it is frequently interchangeable with ''unconscious,'' it usually implies something more definitely psychic. It denotes (1) the forgotten, (2) the purposeless, (3) the unnoticed, (4) the mechanized, (5) the reproducible, (6) the productive, (7) the psychic real.[1] It is also used to describe (8) simultaneously existing secondary streams of consciousness thought to appear in the pathological phenomena of divided personality, (9) and dissociated states which some writers believe to be synthesized into a subliminal, submerged self and to constitute a large part of mind.[2] The first three uses of the term subconscious (or unconscious) are descriptive of facts of experience, the 5th, 6th and 7th are metaphysical interpretations of results whose causes are unknown, and the fourth and fifth are a mixture of facts and

[1]Hellpach: Das Unbewusste, *Centralblatt f. Nervenheilkunde u. Psychiatrie,* 1908, XXXI, pp. 65-66.

[2]Summary by Prince. A Symposium on the Subconscious. *Jour. of Abnormal Psy.*, 1907-8, II, pp. 69 ff.

interpretation; the last two uses are descriptive and explantory of anomalies of consciousness and will be considered later.

Used in the sense of unnoticed or unattended, "subconscious" (or "unconscious") belongs to the realm of experience and is used in the sense of "least consciousness." As such no metaphysical implications are involved. But it is an easy step from dim consciousness to complete loss of consciousness, and many authors make the transition, including, as psychic, processes beyond the point where we are even dimly aware of them. Discussion as to the psychic nature of processes of which we are not introspectively aware began with Leibnitz[1] and the later treatment of Hamilton, Mill, Brentano and Carpenter. The use of the conception in explanation of the pathological phenomena of multiple personality, hysterical manifestations, hypnotism and other anomalies of consciousness has more recently brought the question into prominence again. The following are most of the representative arguments for the hypothesis that the mental life is wider than experience, with the opposing views:

(1) Total perceptions must be composed of an infinite number of infra-conscious sensations. The roar of the ocean is made up of the imperceptible sound of each wave, the greenness of the forest of the color of each separate leaf.[2] "But," it is answered, "this is not necessarily so, for a sum of magnitudes differs from its parts, not merely quantitively, but qualitatively." A lesser degree than zero changes water not partially, but completely to ice.[3] A sufficient quantity of the cause may be necessary to produce any of the effect.[4] The infra-sensible stimuli affect the nerve and help the birth of the sensation when other stimuli come, but it is a matter till then of the nerve-cell only.[5]

(2) By far the larger part of our spiritual possessions are not in consciousness, but are the forgotten memories, unconscious habits and the results of early experiences. That these are really concerned is shown by cases where delirious patients speak the forgotten language of early childhood,

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[1]Leibnitz: New Essays Concerning Human Understanding (trans.), N. Y. 1896. pp. 47-52.
Hamilton, Sir Wm.: Lectures on Metaphysics, Edin., 1877, Vol. 1, p. 339 ff.
Mill, J. S.: An Examination of Sir Wm. Hamilton's Philosophy, London, 1878, Vol. 1, ch. 8.
Brentano, F.: Psychologie, Leipzig, 1874, Ch. 4.
[2]Leibnitz: *op. cit.*, pp. 47-52.
Hamilton: *op. cit.* p. 339 f.
[3]Brentano: *loc. cit.*
[4]Mill: *loc. cit.*
[5]James, Wm.: Principles of Psychology, N. Y. 1902. Vol. 1, p. 159.

and idiots remember things they have heard but not understood, also the oft cited case of the ignorant servant who quoted in delirium passages of Hebrew she had heard her master read. Contrary opinion contends that not the ideas, but the power of reproducing them remains latent, physiological modifications only being concerned. Understanding what one hears is different from consciousness, and probably the idiots and the servant were aware of the sounds, but not of their import. In memories, not the concept is conserved, as Herbart believed, but "molecular habits of the brain."[1] "Unconscious psychic dispositions" would have to be assumed just as much for newly produced as reproduced ideas.

(3) Habitual actions which are at first entirely conscious become mechanized and unconscious. Complete activities formerly requiring a voluntary initiation of every act in the series, now run on of themselves when consciously started. One party holds this fact to be evidence that the psychic side exists unconsciously; the other, that the process has become merely a matter of physiology.

(4) Unconscious psychic processes are manifested by results existing in consciousness—results whose underlying processes are entirely unknown to us. Examples are the perception of depth from the fusion of simultaneous double retinal images, the perception of direction of sound by its relative intensity in the two ears, and other judgments or inferences spontaneously made without consciousness of the reasons or of the underlying principles. Also, there are sometimes present in the after-image details which were not seen in the original image.[2] Against the last example Brentano urges that the after-image is really due to a prolongation of the physiological excitation. In the original perception consciousness was occupied with something else, but is free later so that the unnoticed phase makes itself evident in the after-image. A similar argument, *i. e.*, that details of which we were unconscious in the original experience are frequently observed later in the memory image, might be met by the explanation that such details were actually present, but were not in the focus of attention.

A physiological explanation is thought to meet the next three arguments.

(5) By turning our attention to something entirely different we are frequently enabled to recall a forgotten name, etc., which has been supposed to prove that an unconscious pro-

[1]Münsterberg, H.: Grundzüge, d. Psychologie, Leipzig, 1900, pp. 223-224.

[2]Helmholtz: Handbuch d. physiologischen Optik. Hamburg, 1896. pp. 602, 962.

cess has gone on to call it up. Profound sleep may recover lost ideas, because, it is held, the process goes on undisturbed by our fruitless efforts. (A refreshed and rested brain may be responsible for quicker association.)

(6) The same thing is seen in the recall of forgotten facts, and even unnoticed details of a former experience, while a different stream of conscious thought flows along beside it. Automatic writing, "crystal gazing" or "shell hearing" may make known to us facts which it has been impossible for us to recall or even of which we were "unconscious" before. (The automatic writing is explained as a purely physiological process, with no "detached consciousness" and the "unconscious" perceptions as conscious but rapidly forgotten.)

(7) Activities similar to conscious activities except that they are carried on during abstraction and so lack the conscious quality are supposed to show unconscious psychic processes. For example, one may take one's way along the street, choosing one of many possible directions, while one is so absorbed in deep thought that he is unconscious of what he is doing. Or one may hear a sound, detect an odor or feel a pressure while absorbed without being conscious of it, but when the engrossing thought is past it may come to full consciousness. Bleuler, who thinks consciousness occurs only with the association of a complex with the ego-complex,[1] explains such cases by saying that the object was perceived by the psyche, but not so associated. The explanation by those opposed is that what we have is perception with rapid oblivescence.

(8) "Mediate associations where ideas arise which have no causal connection in consciousness show the efficiency of unconscious links." Jerusalem reports such a case, as follows: A man was busy at his work when suddenly there flashed before him a scene witnessed many years before, which was totally out of keeping with his present occupation. Search for the connecting link finally resulted in finding a tiny hidden flower, which he had not known was present, and which had been directly associated with the earlier experience. The odor, of which he was "unconscious" had probably been responsible for the association. Wundt answers to this and like cases that the odor was conscious but unnoticed,[2] and other opponents take the same attitude. Scripture performed a series of experiments which seemed to show that associations were formed between nonsense syllables by iden-

[1]Bleuler, E.: Bewusstsein und Association, *Journal f. Psy. u. Neurol.* VI, 1906, 154. Re-published in C. G. Jung's Diagnostische Associationsstudien, Leipzig, 1906. I. 257.

[2]Wundt's *Philosophische Studien,* X, 1894. S. 326-8.

tical characters written on the outer part of the cards used so that they were not noticed.[1] Cordes and Messer think they find cases of mediate association, but Münsterberg,[2] W. G. Smith and Howe[3] get only negative results. Pierce[4] suggests as an explanation for cases like finding one's self saying a word which later we discover to be written somewhere but which we have not "seen," as the 'translation' of the image into another field than that in which it was received. Out of 892 observations of "free rising" ideas Kiesow reports that 41% could be accounted for, and believes that his experiment proves all such links to be conscious and either ideational or emotional in character.[5] By some, "free rising ideas" receive a physiological explanation.

(9) Closely connected with mediate associations are the sudden flashes and insights—ideas which apparently come from nowhere—and the exaggerated and more brilliant form of the same thing seen in the inspirations of the genius and the fancies of the poet. Not an unconscious ideational connection, but a purely physiological basis of the association satisfies the opponents of the "unconscious."

(10) Decisions have sometimes been reached or problems worked out in sleep. In dreams the result may be arrived at, but the setting may be fantastic or absurd. Here, too, the physiological mechanism may been have started and carried the whole thing out by itself, or if the process is accompanied by dreaming it is none the less conscious for the fact that associations are lacking to make the setting normal.

(11) Development of emotional states is often unconscious. Prejudices are formed for no conscious reason; appreciation of art rests on unconscious factors; a man may be in love without being conscious of it. Here the usage of the term rests on the identification of consciousness and self-consciousness. Because an attitude is "unreasoned" it is not necessarily unconscious. Experiencing an emotion or idea and having it as an object of consciousness are two different

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[1]Scripture, E. W.: Über den associativen Verlauf der Vorstellungen, Leipzig, 1891. Diss. pp. 76-87.

Cordes, G.: Experimentelle Untersuchungen über Association. *Philos. Studien*, XVII. 1901. S. 73.

Messer, A.: Experimentell-psychologische Untersuchungen über das Denken, *Arch. f. d. gesam. Psy.*, VIII. 1906, 63 ff.

[2]Münsterberg, H.: *Beiträge*, Bd. 4 1892 S. 2-8.

Smith, W. G.: *Mind*, N. S. III. 1894. p. 301.

[3]*Am. Jour. Psy.*, VI, 1894. pp. 239-41.

[4]*Jour. Phil. Psy. & Sc. Meth.*, I, 1904. pp. 400-3.

[5]Kiesow, F.: Ueber sogenannte "freisteigende" Vorstellungen, usw. *Arch. f. d. Gesam. Psy.*, VI, 1906. 357-90.

matters. (James.) The man in love is conscious of each feeling and sensation, but not of the fact itself (Brentano).

Unconscious and Subconscious as Used by Psychopathologists

The use of the terms "unconscious" or "subconscious" by the psychopathologists to describe anomalies of consciousness deserves special attention because the sense is somewhat different from any of the preceding cases. Consciousness is conceived as split into two consciousnesses, one usually more firmly knit together and predominant than the other, the secondary consciousness, "co-consciousness," or "subconsciousness." These two (or sometimes more) consciousnesses may exist simultaneously or alternate with each other. Prince explains the phenomena thus. Ideas making up an experience tend to become organized into a complex which may be a subject, time or mood complex. Dissociation of personality may take its line of cleavage along any one of these three complexes and in abnormal conditions a complex which is only one side of a character may become the main or sole complex of the new personality. Complexes may be artificially organized in hypnosis, trances, etc. The formation of complexes has its basis in the organization of the neurones into complexes, which retain their organization so that stimulation of one element starts the whole process. Physiological complexes can be conserved despite absence of awareness in the original experience. Strong organization of physiological complexes together with lowered physiological threshold and decreased inhibition, might render them accessible to minimal stimulation, whether peripheral or central, and cause them to function automatically as different groups of ideas. If the threshold were sufficiently low, it might become "co-conscious," without entering the field of personal consciousness. This co-consciousness is really conscious because it behaves so, being able to solve problems, and because it says it is conscious. For Prince there is no normal "subconscious or subliminal self or hidden self."

Janet[1] who likewise limits "subconscious" to the pathological co-activity of divided personality, thinks there may be a group of co-existing ideas in the normal individual because "pathological phenomena have their germ in normal physiology." This aggregation is due to weakness in power of synthesis. In hysteria the power of psychic synthesis is so weakened and consciousness so narrow that when one per-

[1]Janet, P.: A Symposium on the Subconscious. *Jour. Abnormal Psy.*, 1907-8, II, p. 62.

ceives an impression he is inaccessible to others. Sometimes he is unable to receive impressions from more than one sense realm, or he may even be able to obtain data from impressions from one side of the body only. Ideas are not associated with one another as with normal people, but every idea takes up the whole narrow activity of consciousness.

Sidis, on the other hand, considers a sub-conscious self the possession of every individual normal and abnormal. The subconscious is not an unconscious physiological mechanism, it is a secondary consciousness, a secondary self.[1] It may possess some degree of self-consciousness, may grow and develop. "As a rule the stream of sub-waking consciousness is broader than that of waking consciousness, so that the submerged, sub-waking self knows the life of the upper, primary, waking self, but the latter does not know[2] the former. This self is manifested by all the facts of "crystal gazing," "shell hearing," automatic writing and the like. They "reveal the presence of a secondary, submerged, hyperæsthetic consciousness that sees, hears and perceives what is outside the range of perception of the primary personal self." This sub-awaking[3] self shows itself present in post-hypnotic suggestion, "shell-hearing," "crystal vision," etc. It is extraordinarily plastic and devoid of all personal character. The subconscious is by no means identical with states of low intensity, but includes psychic states ranging from the lowest to the highest tension and vividness of mental activity.[4] In the functional relation of nervous elements he finds the physiological basis for the disaggregation of consciousness. The neurons form combinations of ever increasing complexity, and the more complex their organization the greater the organization of psychic units into systems. The individual mind is therefore a complex system of many minds. "There may be as many different personalities, parasitic or secondary, as there are possible combinations and disaggregations of psychophysiological aggregates." A neuron aggregate, entering into association with other aggregates and being called into activity from as many different directions as there are aggregates in the associated cluster, has its neuron energy kept within the limits of the physiological level. A dissociated neuron aggregate, on the contrary, is not affected by the activity of the other aggregates; it is rarely called upon to function and stores up a great amount of neuron energy,—

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[1]Sidis, B. and Goodhart, S. P.: Multiple Personalty, N. Y., 1905, p. 128.
[2]*Ibid.*, p. 138.
[3]*Ibid.*, p. 45 and 184.
[4]*Ibid.*, p. 45 and 184.

with the equilibrium of the neuron aggregates, with the synthesis of the dissociated systems, the subconscious eruptions, attacks or 'seizures' vanish never to return.[1]

The explanation of Breuer and Freud for like phenomena is similar to that of Sidis. In some cases we find that "great complexes of ideas and complex psychic processes, rich in consequences, remain completely unconscious in many patients and coexist with the conscious psychic life."[2]

Cleavage is usually caused by the suppression from consciousness of a painful experience. Ideas producing the hysterical phenomena, though of long standing, are lively and actually present, their continued liveliness being due to a dearth of associations and external impressions. Cure consists in associating the suppressed experience with the rest of consciousness, for when an emotion is denied expression in reaction the intra-cerebral excitation is greatly increased but used neither in motor nor associative activity, and in some cases abnormal reactions enter and there is an "anomalous expression of the emotional life." When the complex is associated with other neural complexes, its excess energy discharges itself. Phenomena of daily life show the repression of painful memories and evidences of the effect of unconscious ideas, such as forgetting good resolutions or the return of a desired but borrowed book, and many symptomatic and accidental acts. Unconscious motives determine many of our actions. Dream work is a complex thought structure formed in the daytime and not discharged, leaving a remnant which persists and would disturb sleep were it not converted into dreams.

Jung[3] finds longer reaction times when the stimulus word is associated with an idea complex possessing a strong feeling tone. This complex, momentarily separated from consciousness, exercises an effect which concurs with the ego-complex. The "constellating" of an association is mostly unconscious, the complex playing the rôle of a quasi-independent existence, a "second consciousness."

GENERAL DISCUSSION OF THE ABOVE MENTIONED CONCEPTS

The above are the representative uses of the terms "conscious," "subconscious" and "unconscious," with the disputes therein involved. Objections to speaking of "unconscious psychic" processes are mainly on the logical ground that un-

[1]Sidis, B.: Psychopathological Researches, N. Y., 1902, p. 212.

[2]Breuer and Freud: Studien über Hysterie, Leipzig, 1895, p. 194.

[3]Jung: Ueber das Verhalten der Reactionszeit beim Assoziationsexperimente. *Journal f. Psy. u. Neurol.*, VI. 1905. 29. (Republished in C. G. Jung's Diagnostische Assoziationsstudien, Leipzig, 1906, I. 221 ff.)

conscious and psychic are contradictory terms. Metaphysical considerations on the other hand are responsible for the contrary opinion, for it is held that the law of universal causation must hold for the mental as well as the physical world. Changes often occur in consciousness with no consciousness, *i. e.*, with no consciously observable cause; therefore they must have an unconscious mental cause. The problem reduces therefore to one of epistemology;[1] the identification of consciousness and the psychic or the extension of "psychic" to cover the accompaniment of all material changes. As Hellpach points out, the unconscious can never be discovered by investigation, but only by hypothesis, by analogy, or metaphysics. He who denies the unconscious retreats to the empirical and has to explain all from the conscious side in which there are vast gaps. If he makes any assumptions he must say that consciousness causes physical changes and these again conscious ones, which is the interactionist's position, or that physical and mental changes are parallel, which is the position of either monistic or dualistic parallelism.[2] The attitude one takes reduces, therefore, ultimately, to a question of his temperament. Practically, it makes little difference whether one assumes the changes going on without consciousness but later affecting it to be complex neural changes only,[3] or changes possessing the conscious character in structure but lacking the conscious quality, or a psychic reality accompanying all existence, or a psychic accompaniment of molecular changes different in degree from those underlying conscious experiences.

Let us consider somewhat more fully the use of the terms "unconscious psychic process" in this metaphysical sense of the psychic accompaniment of physical processes lacking the conscious quality. By consciousness we mean that indefinable ultimate best described as experience or awareness. It is not identical with self-consciousness, which is only consciousness of one's past states of consciousness, immediate or remote. Consciousness is the broader term. Conscious states, however, are those which can become self-conscious later. Consciousness is always more or less complex, the elements entering therein contributing to the character of the whole, which is qualitatively different from these elements. It is the *interconnection* of the psychic processes, *i.e.*, it is the *association* of the elements constituting it. Where association is

[1] Münsterberg, H.: Symposium on the Subconscious, *Jour. Abnormal Psy.* II. 1907-08, p. 28.

[2] Hellpach: Das Unbewusste, *Central. f. Nervenheilkunde und Psychiatrie*, 1908, Bd. 31, S. 65-6.

[3] Münsterberg; Psychotherapy, N. Y., 1909, p. 140; p. 147.

strongest consciousness is most intense. We assume the existence of a psychic side concomitant with all material changes, both conscious and unconscious. "Unconscious" we use as diametrically opposed to "conscious," "psychic process" in the metaphysical sense of the psychic side of a process possessing a concomitant physical side. Such a psychic side we conceive to be present in all organic matter, if not in all matter. With the activity of each neuron, therefore, there is psychic process, but consciousness probably does not occur until there is a complex functioning of neurons in one system or pattern. The pattern may change and shift in its organization, now dropping out some elements now taking up others, but the whole is usually in a more or less close functional connection. It is however conceivable that two or more different complexes may be functioning with sufficient intensity to give different alternating or simultaneously existing streams of consciousness. Association of an aggregate with the personal aggregate is probably necessary for consciousness — in other words, association of elements with the general bodily sensations and feelings which constitute the fundamental part of our personality—what Bleuler probably means by "the association with the ego-complex."

According to this view ideas out of consciousness do not become physiological processes any more than they were such before. We must assume some disintegration of the neuron aggregates underlying the idea and with this disintegration some change in the idea itself, according to which it no longer possesses its former character, but is the psychic accompaniment of the physiological process.

As for the objection to the term "unconscious psychic process," we agree with Lipps[1] that every psychic *process* is unconscious. All that is given in experience is each separate state of consciousness, the process underlying the sequence of ideas or feelings never being a matter of consciousness, but something which is merely inferred. The inspirations of the poet and the associations of the genius are not more spontaneous than those of the ordinary man, only richer and more varied. The ordinary man may be able to trace and explain the sequences better than his more fortunate brother, but the processes underlying them are none the less unconscious.

As for "free-rising" ideas, or "mediate" associations, conscious connective links, rapidly forgotten, without doubt exist in many cases. When the idea can be traced to an association started from some external cause, of which the subject was absolutely unconscious, a peripheral physiological

[1]Lipps, T.: Leitfaden d. Psychologie, Leipzig, 1909, p. 83 f.

excitation has probably set into action a neuron complex out of connection with the main system, which is concerned in some other different state of consciousness. When this widens and the emphasis of activity shifts, the aggregate stimulated peripherally, without conscious, but with psychic, accompaniment may be taken up in the new arrangement of neuron complexes and become conscious. But sometimes an idea enters with no traceable connection. Here aggregates concerned in the "free rising" idea may be in a state of functional activity of a greater or less degree but separated from the centre of activity. Cells concerned but slightly in the conscious processes of the moment may set in activity others involved in the detached aggregate, which functions then with such completeness as to shift the centre of activity from the original to the new position, the new idea becoming the centre of consciousness.

The divided consciousness of multiple personality, and similar states sometimes experienced by normal individuals in dreams or abstracted conditions where consciousness seems to be divided into two alternating or coincident streams, is of the same general character as consciousness. The term "co-consciousness" is a better name for this experience than "subconsciousness," and is more definite in its meaning. Used in such a sense "subconscious" is too easily extended, even by the writer who so uses it, to cover something which is literally under consciousness, out of which consciousness arises and into which it descends. Used in such a way, it takes the place of the older concept of the "soul" as an independent creative entity. Just as the soul was responsible for our actions or looked out upon our thoughts, so its successor, the "subconscious self" is supposed to do.

Consciousness does not fade off from distinctness by ever fainter degrees into unconsciousness. Facts in the margin of consciousness are qualitatively the same as those in the focus, but the difference between the outer limits of the margin and the region beyond is absolute. "Subconscious," when used to denote the periphery of the conscious field, is a term descriptive of a condition of actual consciousness, different in degree; but as it is too easily extended to describe processes outside of consciousness, "perceptual" is a better term.

Analysis shows that expressions like "resting back on the subconscious" in prayer and meditation mean the relieving of mental tension by widening attention, so that activity can shift from newer, less firmly established association complexes to older, well developed complexes which have had survival value. The individual is "larger than his conscious-

ness,'' in that consciousness at best is so narrow as to embrace but a small part of the results of his own past habits and experiences, and those of the race seen in tendencies, appetencies or instincts. In such a sense any present experience is only to a small degree determined by conscious factors. One's motives for action are seldom clearly analyzed or made focal in consciousness. Oftener they are entirely without consciousness, being the results of past experiences and training which have developed characteristic modes of spontaneous response.

CONSCIOUSNESS IN ANIMALS

No objective proof of consciousness in animals is possible,[1] but the assumption of consciousness in them rests on inference, just as it does in our fellow beings, for the only place it can be positively known is in the individual himself. Denying the possibility of comparative psychology would therefore logically result in a like attitude toward human psychology.[2] Any objective criterion of consciousness must be arbitrary. "Learning'' or "modifiability of behavior'' as an indication of its presence is not good, for there is evidence that plants learn,[3] and even material[4] objects adapt themselves to repeated stimuli or changed conditions as the seasoning of a violin to strains of the master. There are also some indications that human learning goes on unconsciously.

III. The Relation of Consciousness to Learning

The relation of consciousness to learning has received some discussion as well as experimental testing. The problem of learning in general I have reviewed elsewhere[5] and shall consider here only the results bearing directly on the subject in hand.

THE LEARNING PROCESS

We may define learning as the formation of associations between certain stimuli and definite modes of reaction. The simpler and less varied the stimuli the simpler the learning process will necessarily be, and the more permanent the value of

[1]Yerkes, R. M.: Objective Nomenclature, Comparative Psychology and Animal Behavior, *Jour Comp. Neur. and Psy.*, 1906, XVI, p. 388.

[2]Claparède, E.: La psychologie comparée, est-elle légitime? *Arch. de psy.*, 1905-6, V. p. 34.

[3]Darwin and Pertz: On the Artificial Production of Rhythm in Plants. *Annals of Bot.*, 1903, XVII, pp. 93-106.

[4]Washburn, M. F.: Animal Mind, N. Y., 1908, p. 33.
Claparède, E.: The Consciousness of Animals. *Internat. Quart.*, 1903-4, VIII, pp. 296-315.

[5]Ellison, L.: The Acquisition of Technical Skill, *Ped. Sem.*, 1909, XVI, pp. 49-63.

the associations formed, the simplest form probably being that in the case of lower animals where the association is between a single stimulus and a simple movement, the highest and most complex form in man, where complicated movements must often be preceded by a train of thought possessing little motor accompaniment. The simplest form of learning involves, then, direct motor response to a simple stimulus, the highest, however, lacks much of this motor element, being for the most part an association of symbols, such as the growth in meaning of words, and the power of generalization from previous experience. Most learning involves both these factors.

Observation and experiment goes to show that learning to meet any new situation involves a specialization and perfection of some part of an already existing habit or mental possession. As Morgan points out, effective consciousness[1] finds itself a partner in a "going concern." The performance of the instinctive act whose co-ordinations are hereditary, and the consciousness such a performance evokes, are simultaneous.[2] The behavior and the conditions producing it occupy consciousness, but "the effects of the behavior, as the animal becomes conscious of the acts concerned, serve to complete and render definite the conscious situation. Consciousness, however, probably receives information of the net results of the progress of behavior and not of the minute and separate details of muscular contraction."[3] As Sherrington puts it, "the controlling centres can pick out from some ancestrally given motor reaction some part of it so as to isolate that as a separate movement, and by enhancement this can become a skilled adapted act added to the powers of the individual."[4] When a new movement is initiated an excess of energy is expended and with it occur many more or less random movements; of these, as the effort is repeated, a special movement, or a special series, finally stands out from the scattered mass. The clearer its separateness from the rest, the more vivid its conscious accompaniment and the power of conscious control. Consciousness of the way a movement feels is necessary for its voluntary performance, hence, as Judd's[5] experiments show, an abstract idea cannot

[1]Morgan, C. L.: Introduction to Comparative Psychology, N. Y., 1906, p. 51.
[2]*Ibid.*, pp. 99, 101.
[3]*Ibid.*, p. 105.
[4]Sherrington, C. S.: Integrative Action of the Nervous System, N. Y., 1906, p. 389.
[5]Judd, C. H.: Practice and its Effects on the Perception of Illusions, *Psy. Rev.*, 1902, IX, pp. 27-59.

take the place of direct perceptual experience. The way to get control of a movement as the experiments of Bair[1] and of Swift[2] show, is by working outward from some general movement over which we already have control. In Bair's experiment on learning to move the ears, the subjects began with the muscles over which they had conscious control, such as raising the brow, clinching the teeth, making more and more strenuous effort to get closer to the ear, an excess of motor energy being discharged with proximate muscles. "As soon as the sensation arising from the movement of the ear was associated with the concomitant sensations of muscles close to it, over which there was already voluntary control, there was a basis for learning the voluntary control of the ear." The definite idea of the movement given by electrical stimulation of the *retrahens* muscle was not sufficient to produce the movement, but it gave a general idea as to the direction the innervation was to take. As control developed attention was narrowed down from the general sensation of the adjacent muscles to that of the specific movement sought for. Likewise, in the control of the reflex wink, Swift found it necessary to begin with the muscles around the eyes over which there was conscious control. What Bair[3] says in regard to the general ability given by special training, *e. g.*, "to a new situation we react by a general discriminative reaction and are more likely to hit on a favorable response than without this special training," is true of all learning. For no matter what new acquisition is undertaken, if it is possible to master it, some previous general training has either been developed by the individual or through the inherited co-ordinations of his ancestors. Experiments on acquisitions of a more complex kind show the same fact—attentive consciousness cannot be directly and advantageously applied at first, because of the multiplicity of details which overwhelm it. The new experience calls up too many old associations which are not pertinent. Such facts account for the rapid rise of the learning curve at first, when responses are selected from a mass of older habitual reactions, and its slower ascent later, when associations really new are being formed.

CLEAR CONSCIOUSNESS AND LEARNING

The importance of clear consciousness in learning is shown by the following facts. Experiences causing greatest atten-

[1]Bair, J. H.: Development of Voluntary Control, *Psy. Rev.*, VIII, p. 499.

[2]Swift, E. J.: Studies in the Physiology and Psychology of Learning, *Am. Jour. Psy.*, 1903, XIV, pp. 200-251.

[3]Bair, J. H.: The Practice Curve, *Psy. Rev., Mon. Sup.*, 1902 V.

tion are best remembered. Desire to succeed and intense effort are necessary for progress, which means that one must attend closely to the matter at hand. Even in learning of a purely muscular sort, where attention to the movement itself has been found to be a hindrance, attention to the objective features of the task is required for the perfection of the unconscious or dimly conscious part of the reaction. The fact that subjects of a given mental type are most interfered with in their learning, by distractions appealing to that type of imagery, shows that undisturbed consciousness is essential. Trying to recite a syllable series is more effective in establishing the syllables than merely reading them,[1] because of the narrower attention required. Figures drawn with the left hand are better remembered than those drawn with the right, for the same reason;[2] the greater ease of remembering sense material as compared with nonsense is also probably due in part to the easier application of attention.

Results from experiments on cross education point to like conditions, for the more similar the training and the test material the greater the transference.[3] Improvement consists in more economic methods of work,[4] and is essentially "attention training." Transference consists in the carrying over of right hand "methods" to the left hand. Perhaps the most adequate study of this problem is a recent one by Fracker,[5] who finds that the most essential element in transference is imagery and that improvement occurs if imagery is developed in the training series which can be transferred and advantageously used in the test series. It may be subconsciously developed, but if it comes to be consciously recognized, the improvement is more rapid. "The rate of improvement seems to depend directly upon the conscious recognition of the imagery and upon attention to its use. The transference of elements is a conscious transference." Improvement during intervals of no practice seems to be due in part to freshness and better attention, in part to the fact that interfering habits are forgotten, so that better and more

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[1]Witasek, S.: Ueber Lesen und Rezitieren. . *Zeits. f. Psy.*, 1907 Bd. 44; pp. 161-185; 246-282

Katzaroff, D.: Expériences sur le rôle de la récitation, *Arch. de Psy.*, 1908, VII, pp. 255-8.

[2]Rowe and Washburn: The Motor Memory of the Left Hand, *Am. Jour. Psy.*, 1908, XIX, p. 243.

[3]Ebert u. Meumann: Ueber einige Grundfragen der Psychologie der Uebungsphänomene, *Arch. f. d. ges. Psy.* 1905, IV, S 1—232.

[4]Swift: *Op. cit.*

[5]Fracker, G. C.: On the Transference of Training in Memory, *Psy. Rev.*, Mon. Sup., IX, 1908, 56-102.

practiced ones may be free to assert themselves.[1] Then, too, attention is not distracted by the new elements of the situation, but can be more economically applied. The value of clear consciousness in learning is that it assists the selecting of good elements from the complex reaction and the eliminating of disadvantageous factors. When the subject is weary he is apt to fall into bad habits which are more difficult to modify because unconscious.

Consciousness of details and elements of a process gradually gives place to consciousness of larger and more complex difficulties. These elements gradually form themselves into larger wholes and consciousness works with greater units. This is true not only of muscular learning, but of more intellectual activities such as typewriting, the telegraph language and chess. As Cleveland[2] puts it, with reference to chess, "learing requires the perfection of the elements and their organization into ever larger groups, so that attention is not bound to details, but left free to forge ahead and anticipate difficulties." In the writing processes, first letters, then words, then sentences are grasped. In chess one grasps the situation by larger and larger wholes. Cleveland puts it thus, "Progress in chess consists in the formation of an increasing symbolism which permits the manipulation of larger and larger complexes. . . . There is something in the purely intellectual life corresponding to motor automatism, which is shown in the ability to think symbolically or abstractly, and thus to handle large masses of detail with a minimum of conscious effort. It involves the increasing ability to take in during a single pulse of attention a larger and larger group of details which means, of course, that the attention is no longer needed for each one."

The importance of the motor element in learning verbal material is without doubt due to clearer consciousness of the task, the material appealing not only to vision, but to hearing and the kinæsthetic senses.

SUBCONSCIOUS AND UNCONSCIOUS LEARNING

Such are some of the observations as to the rôle of consciousness in learning, but much of our learning goes on below consciousness. As Kuhlmann[3] points out, much of our most important learning—the use and functional activity of our own

[1]Book, W. F.: The Psychology of Skill, U. of Montana Bull., No. 53, 1908, p. 6 ff.

[2]Cleveland, A. A.: The Psychology of Chess and Learning to Play it. *Am. Jour. Psy.*, 1907, XVIII, pp. 269-308.

[3]Kuhlmann, F.: The Place of Mental Imagery and Memory among Mental Functions, *Am. Jour. Psy.*, 1905, XVI, p. 337-356.

bodies—goes on with no conscious direction. The digestive apparatus must learn to do its work, and so must other internal organs Early reflexes such as the reflex wink and mimetic expressions, binocular vision, the co-ordination of voluntary muscles, develop without *voluntary* use of incoming stimuli for their guidance.

The very possibility of learning rests on an unconscious basis of physiological endowment. The dullard and the genius are alike dependent upon their physiological inheritance, and the quick wits of the healthy child are as much beyond his conscious control as are those of the feeble defective.

We are not conscious of the "process" underlying our associations, but merely of the results as they present themselves to consciousness. In fact learning may progress without our knowledge of the fact, as is seen in the development of unconscious automatisms. For example, one may develop peculiar manners of gait or expression without knowledge, having unconsciously imitated some one possessing a like peculiarity. Through the ever present suggestions of a new environment we may develop new ideals and new apperceptive attitudes of which we are unconscious until we are taken back to our old surroundings. In learning of a muscular sort we may have been conscious of every sensation leading up to the subsequent habit, without consciousness of the method in which we work, or of the existence of the habit itself. An example is given by Pfungst.[1] Having directed his subjects to think of one of two similarly sounding words of a series to which he would respond with certain arm movements, he was able to tell by the direction of the head or eye movements, of which word they were thinking and to which they expected him to react. By changing his manner of responding he obtained a similar change in their movements. He was also able to tell by head movements of which direction, left or right, his subjects were thinking. He concludes that "the changing of natural movements of expression and the acquisition of new ones are both possible without knowledge of the person."

Our environment is one of the strongest factors in training us, whether it operates consciously or unconsciously. One hears good language continuously, and easily forms the habit of using it himself. The development of our ethical ideals and æsthetic feelings and our very forms of thinking unfold before we are conscious of their existence. Such habit formation rests on instinctive imitation and forms one of the most important classes of learning.

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[1]Pfungst, O.: Das Pferd des Herrn von Osten, Leipzig, 1907, p. 77 ff.

Learning may also progress without consciousness of the end or purpose. Such a fact has its best illustration in the instinctive activities of animals and the play of children and animals. Play is a training process for life where most of the activities required in later life have their initial, though unwitting, development.

The formation and strengthening of associations below consciousness is indicated by some of the laboratory experiments on learning. This must be the explanation of the fact that scattered repetitions, which deal with older associations, give best results. Müller and Pilzecker think the greater strength of the older associations is due to the tendency of an excitation to outlast the stimulus—to a "perseveration tendency"—as a result of which an idea rises of its own accord into consciousness without associative connections. Illustrations other than those found in learning nonsense syllables are the following: The histologist's illusion which occurs after working long and intently with the microscope; images seen with closed eyes often have then the character of the microscopic forms. Similarly when one studies or thinks intently of any subject, carelessly perceived objects tend to take on its character. While studying the anatomy of the internal ear every gas jet or twisted twig was a cochlea, for the writer. It is not uncommon to see, before sleeping, scenes which have passed before the eyes while travelling, or on a tramp. "Crystal vision" may illustrate the same phenomenon, freeing the mind for the appearance of ideas underlying which is this perseveration tendency. This fixing of the association probably goes on physiologically whether the ideas crop out into consciousness or not, for Müller and Pilzecker found that attention to any other engrossing matter prevented their recall, although free reproduction was not a tendency with all their subjects; nor was the hindrance due to preventing the subject from thinking over the series. They conclude that "after the reading of a syllable series, certain physiological processes which serve for the strengthening of the associations formed by the reading of a series continue for a certain time with gradually diminishing intensity."[1]

"Retroactive amnesia" or the forgetting, after a shock, of incidents extending backward from the shock to several hours or more, likewise points to the probability of the physiological fixing of associations.[2]

Experiments on the acquisition of skill show that unconscious habits are developed which consciousness either selects

[1]Müller u. Pilzecker: *Zeit. f. Psych.*, Ergänzungsband I, 1900. p. 196.

[2]Burnham, W. H.: Retroactive Amnesia. *Am. Jour. Psy.*, 1903, XIV, p. 386-7.

or represses. As Swift says, "Consciousness discovers certain methods in operation and approves or disapproves them."[1] Subjects improve by "hitting upon" better ways of working, without any further conscious selection, at first, than the general effort to succeed. Book's experiment shows the same thing. "A mass of old associations are called up, only a few of which are directly serviceable for the work. From these there are unconsciously built up, by the double process of elimination and selection and reorganization, the first elementary associations (letter associations) used, and from these in turn the later, higher order habits. There comes to be . . . a sort of unconscious struggle for existence among the many modes of action, ending in the survival of the one direct and economic way of reaching the goal desired."[2]

Automatization of elements previously conscious occurs in the perfection of all activities, leaving consciousness free to undertake more difficult features.

IV. An Experimental Study of the Relation of Consciousness to Learning

Our own investigations undertook to discover by experiment (1) whether learning is helped by factors which never come into consciousness, or are present only to a minimal degree, (2) whether the formation of a habit of whose existence and development one is unconscious can progress as well under distraction, when consciousness is removed as completely as possible from all the elements which go to make up the habit formation; and finally, to find the rôle of consciousness in learning simple tasks involving, (3) almost no intellectual factor, (4) a complex co-ordination of muscular impluses, and (5) learning of purely intellectual character.

1. *Do Unnoticed Items Assist in the Formation of Associative Links?*

Experiment 1 was suggested by Scripture's experiments on the associative course of ideas,[3] and work of a similar sort,[4] which seemed to show that unnoticed features of a total impression (like an inconspicuous Japanese symbol or a numeral placed beside a word or a picture) could serve as a bond to connect the given word or picture with another word or picture which had been elsewhere accompanied by the same symbol or numeral. The theoreti-

[1]Swift, E. J.: Studies in the Psychology and Physiology of Learning. *Am. Jour. Psy.*, 1903, XIV, p. 201-251.
[2]Book, W. F.: Univ. Montana Bull., No. 53, 1908.
[3]Scripture: *Op. cit.*
[4]Sidis: The Psychology of Suggestion, N. Y., 1898, p. 171.

cal importance of the question and the fact that most attempts to repeat Scripture's work had led to negative results invited a new attack. The plan which we undertook may be illustrated by the following scheme, though the actual execution of the experiment was carried out with greater refinement and in a different way as to details.

The observer is presented with a triple series of meaningless syllables, as in Group I below, and is required to read series *b* a certain number of times and if possible learn it. Series *a* and *c* are of course all the time before his eyes though not involved in his task. After reading *b* the required number of times, his knowledge of it is tested by the "Treffer method," and his success in giving the required syllables recorded. Then after a brief interval he is presented with Group II of which the middle series is the same as one of the side series in Group I, *e. g.*, series *a*, and he is required to read (and learn) series *a* in the same manner in which he has just read (and learned) series *b*.

Group I			Group II		
a	*b*	*c*	*d*	*a*	*e*
jex	mil	peb	miv	jex	hal
yal	hud	yom	sem	yal	juj
bup	gib	lur	coj	bup	pom
dof	dep	zal	fet	dof	das
tem	voz	bic	dib	tem	lef
fuj	pog	vop	vil	fuj	roj
nen	lek	loh	buj	nen	zup
gop	gaj	nat	hix	gop	fab
riz	fiv	jof	kug	riz	uls
mod	yem	wam	len	mod	veb

If *a* is on the average learned with greater ease or completeness than *b*, the inference is that the previous presentation of *a* in indirect vision has somehow been helpful—directly by rendering the syllables individually more familiar, or indirectly through their association with the syllables of series *b* which have in the learning been associated with each other. If *a* is not learned on the average more easily or perfectly than *b* the inference is either that no assistance is gained by the "unconscious" perception of *a* or that the gain is not of sufficient amount to be determined by this method of experimentation.

Such experiments were carried out on two trained observers through a considerable number of days, but it may be said at once that the results were on the whole negative. There was no clear evidence of any advantage. The presumption is that the assistance gained is small in amount—too small to be deter-

mined by this method. Later experiments undertaken expressly to determine the delicacy of the method showed that one reading of the *a* series with full attention had no beneficial effect upon the learning of the *a* series after an interval of ten minutes during which the *b* series had been learned.

Though the results of this series of experiments must therefore be set down as inconclusive, they may have, perhaps, a certain value in other connections and are therefore given in the Appendix of this paper.

2. *The Effect of Attention and Distraction on the Formation of the Motor "Set" (Motorische Einstellung)*

EXPERIMENT 2. The purpose of the second series of experiments was to find the effect on the "*Motorische Einstellung*" of attention and distraction. The term "*Motorische Einstellung*" indicates the effect which repeated lifting of a heavy weight has in making subsequent lighter weights seem too light. It is probably due to a temporary habit of the nervous system. The problem in our case was to discover whether a neural habit of this sort, of whose existence the subject was unaware, would be more readily formed when he was attending to the lifting of the heavy weight than when he was inattentive to it.

The phenomenon of "*Motorische Einstellung*" was first reported by Müller and Schumann.[1] They lifted a moderate weight of, say, 600 grams and, after it, lifted a heavier weight of 2,400 grams to an equal height a certain number of times, in a definite rhythm. Then a weight of 800 grams was lifted and found to seem lighter than the 600 grams, lifted before the training with the weight of 2,400 grams. They explain the illusion by saying that the 800 grams, which is lifted with an unusually powerful impulse after the work with the weight of 2,400 grams, rises with unusual speed and therefore seems lighter than the first weight, because we are apt to judge as lighter a weight which raises more quickly. The repetition of the lifting of the heavy weight has set up a tendency in certain sub-cortical centres to discharge automatically with a somewhat extra intensity. Experimentation of this kind was carried further by Steffens.[2]

The apparatus used is pictured in the accompanying cut. Two boards measuring about eighteen inches long were clamped to the sides of the bottom of a chair so that the ends

[1]Müller u. Schumann: Ueber die psychologischen Grundlagen der Vergleichung gehobener Gewichte, *Pflüger's Archiv*, XLV, 1889, 37-122.

[2]Steffens: Ueber die motorische Einstellung. *Zeits. f. Psy.*, Bd. 23, S. 240-308.

extended about seven inches beyond the front edge. Holes were bored near the forward ends of the boards and through these were passed the ends of two handles by which the weights were lifted. The upper parts of the handles were made of wood and were provided with grooves into which fitted the fingers of the observer, enabling him to hold the handles firmly and in the same way each time he lifted. The handles below the board consisted of brass rods having at their lower ends disks of wood, on which the weights rested. An iron needle was passed through each brass rod in the middle, making it possible to raise the handles only a given distance. To prevent the needles hitting against the boards with a jar, a string was fastened in front of the chair, by means of two iron standards clamped to the table, at such a height that the observer's hands would touch the string before the needles came in contact with the boards; as soon as the hand touched the string the weight was lowered. A disk of cork was used on each handle to prevent the clinking of the weights against each other. The entire weight of each handle with the cork disk was 100 grams.

The chair stood on one of the large laboratory tables. As far as possible from the observer a metronome was placed, its noise being deadened by a cloth pad between it and the table. The experimenter sat at the side of the table to the observer's left, and changed the weights as the experiment required. These were flat and circular in form with a rather large slit so that they would slip on and off the handles easily.

The method of the experiment was this: The right-hand weight was always the standard, and was always kept at 300 grams, *i. e.*, a 200 gr. weight plus the weight of the handles. By trying different weights a weight was found for the left hand which usually seemed equal to the right-hand weight. Owing to the difference in strength between the right and left hands this was actually a weight much smaller than the standard. Since practice was apt to increase the strength of the left hand, it was necessary to determine what this weight was before every experiment; and doing this counteracted also any influence which might have been carried over from lifting heavy weights in the experiment of a previous day. After determining the apparently equal weight, twenty judgments were made, upon weights offered for comparison with the standard (300 grams in the right hand), four with the weight which had been judged equal, and four each with weights ten and twenty grams above and ten and twenty grams below the "equal" weight. If the judgments were perfect the results would of course show four judgments "equal," eight "heavier" and eight "lighter." As a matter of fact they

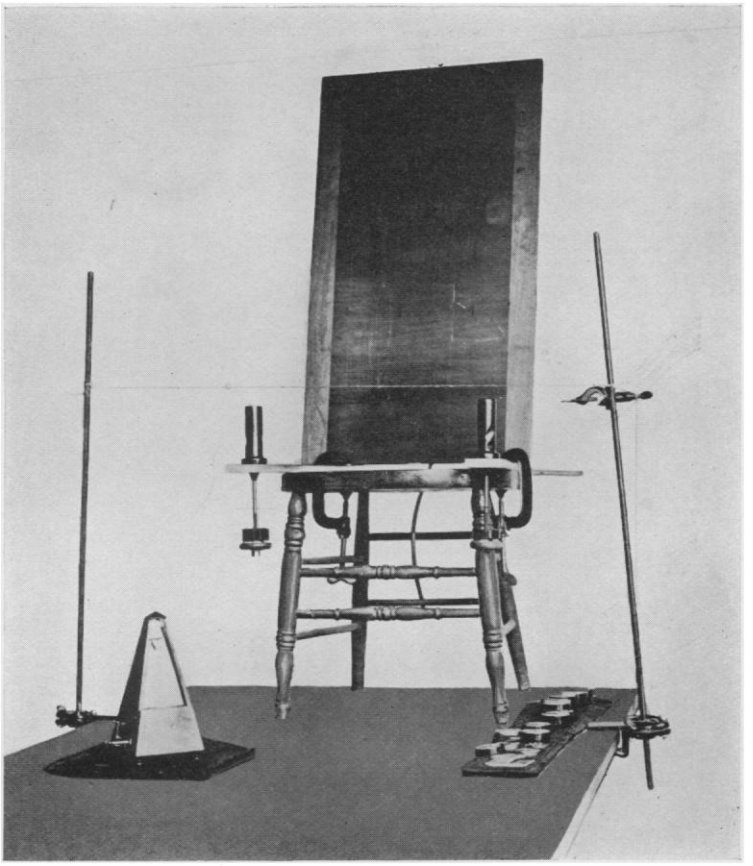

Fig. I.

varied a little, this way and that, as is common in such experiments. The lifting was done rhythmically to the stroke of the metronome, which beat at about four per second for the different observers, some requiring a slower rhythm than others. The rhythm was constant, however, for each subject. At "one" the standard was raised, at "two" lowered, on "three" the comparison weight was raised and on "four" lowered.

The results of the twenty lifts just described served as a basis of comparison for similar lifts after a period of lifting a heavier weight to establish the *Einstellung*. This heavy weight, which was called the "training" weight, was for all subjects a weight twice as great as the one which had seemed equal. The experiment here differed a little in its method for the lifting "with attention" and "with distraction," though the actual weight lifted and the rhythm for lifting were the same for each. In the experiment "with attention," the subject was told that he must determine, by estimation, a weight twice that of the standard, and that he would be given two weights above and two weights below this double weight, and sometimes the double weight itself. He was to raise the standard just as he had done in the previous judgments of equals, which would aid him in his judgment, and he was to judge as quickly as possible. Here the standard was raised on "one," lowered on "two," a pause on "three," the variable raised on "four," lowered on "five," and the judgment given immediately. While the judgment was being given the experimenter shifted the weights, and the subject began to raise the standard in nearly all cases after the sixth count. The method of lifting was at first not carried out in this three-six rhythm, but in a two-four rhythm; but was changed after three days of experimentation to make the rhythm the same for the experiments "with attention" and "with distraction." All the results are incorporated in the tables which follow, as the change of rhythm seemed to have no disturbing effect. Ten judgments were made, four of the weights being greater than the "double" weight, four less, and two the "double weight" itself, so that the actual weight lifted amounted to lifting the double weight ten times. Immediately after giving the tenth judgment the five original (*i. e.*, nearly "equal") weights were compared with the standard, to test the *Einstellung*, and the results recorded. After a rest of from one to two minutes the double weight was raised five times more, in the manner just described, to refresh the *Einstellung;* and immediately after, the original (nearly "equal") weights were again compared. This was done until the training weight had been raised twenty times in all and the original weights had been compared twenty times. In schematic form the ex-

periment was: (1) to determine a weight which when lifted by the left hand should seem equal to the standard weight, when lifted by the right hand. This was done by offering the original weights in such a way that the "equal" weight was raised four times, the ten and twenty grams "heavier," four times each, and the ten and twenty grams lighter, four times each. (2) Ten lifts of the training weight, followed by five comparisons of the original weights arranged according to a regular permutation. (3) Five lifts of the training weight, with five judgments of the original weights. (4) Repetition of (3). (5) Repetition of (3).

The experiment "with distraction" differed from that with full attention only in so far as lifting the training weight was concerned. Here the "double" weight only was lifted ten times, with a pause, then five times with a pause, and so on, until twenty lifts had been made; the actual weight lifted, however, amounted to the same for both forms of the experiment. While the observer was lifting the training weight in the "distraction" experiment, the experimenter read as distinctly as possible from some interesting reading matter. After the lifting of the original weights, which immediately followed that of the training weight, the subject was asked to give the content of what had been read, and a record was made of his success.

Four university students of psychology, two men and two women, served as observers. The number of experiments per observer varied from 14 for observer I, to 28 for observer IV, owing to modifications made necessary by the differences of the individual observers. Each experiment represents twenty lifts for the original weights, twenty for the training weight, and twenty again for the original weights.

The *Einstellung* was present unmistakably in the case of each observer. Observer I showed a clear and decided difference in the intensity of the *Einstellung* under the two conditions of the experiment, the effect being much greater when the training weight was lifted with attention than where distraction was used. This is true for the total and also for all except one of the single pairs of days on which experiments with attention and with distraction were made. The other observers, however, showed this difference but slightly or not at all. The difference was so clear for observer I that an explanation was sought for the indefiniteness of the records of the other three observers. As none could be found at first for observer IV, his work was continued until 18 complete experiments had been performed. The difficulty was discovered for observers II and III and the experiment modified after 12 complete experiments. The following table gives the

results obtained from the work just described. The first column represents the observer, the second the number of

TABLE I

	No. of lifts	Ra			Ta			Rd			Td			Dif. a			Dif. d			a—d		
		L	E	H	L	E	H	L	E	H	L	E	H	L	E	H	L	E	H	L	E	H
Obs. I	140	49	50	41	113	21	6	38	56	46	79	45	16	+64	−29	−35	+41	−11	−30	+23	−18	−5
II	140	50	36	54	108	22	10	49	40	51	103	20	7	+58	−14	−44	+54	−20	−34	+ 4	+6	−10
III	120	42	36	42	99	13	8	41	40	39	96	22	2	+57	−23	−34	+55	−8	−37	+ 2	+3	− 5
IV	180	48	85	47	105	67	8	43	88	49	107	64	9	+57	−8	−39	+64	−24	−40	− 7	+6	+1

lifts, the third (*Ra*) the results before training on days when the training weight was lifted with attention, the fourth (*Ta*) the results after training on days when the training weight

was lifted with attention. Column *Rd* contains the results from the lifting of the original weights before training on the days of the "distraction experiment," and *Td*, those obtained after lifting the training weight on the same days. *Dif. a* shows the difference between the results before and after the training weight, in other words the amount of the *Einstellung*, for the experiments with attention. *Dif. d* gives amount of the *Einstellung* for the distraction experiments. Column *a—d* gives the difference between the *Einstellungen* in the two cases. L, E, H, stand for "lighter," "equal," and "heavier" cases respectively. It will be noticed that some superiority of the *Einstellung* with attention exists over that with distraction except for observer IV, in whose case the opposite is true.

The *Einstellung* came out so clearly in both forms of the experiment with observers II and III, that it was thought that the training weight was so heavy as to give a tolerably intense *Einstellung*, irrespective of attention and distraction. It was therefore reduced a hundred grams to make the *Einstellung* more moderate, and the greater effect "with attention" immediately showed clearly against that "with distraction." The explanation for observer IV was different, and was obtained by an examination of the columns giving the results before the training weight had been lifted (columns *Ra* and *Rd*). The equal cases should number something near one-fifth of the total number and the heavier and lighter about two-fifths each; but the proportion is almost reversed, showing that weights just above and just below the "equal" weights were not discriminated from the "equal." To remedy this difficulty the training weight was kept as before, but the original weights were decreased (and increased) from 10 and 20 grams below and above the "equal" to 20 and 40 grams below and above, in order to make the possibility of discriminating greater. His results then showed the same tendencies as the other observers. Table II gives the results. The lettering of the columns has the same significance as for the preceding table. The first line of figures for each observer reading across the table gives the results of the modified experiment. The second gives the combined results of the first and second form. Observer I, performing the experiment only in its original form, is represented by but one line of figures.

After the experiment was closed a final test was made with each observer both with distraction and with attention, but the observer was asked to notice his manner of lifting, and to see if it differed subjectively in either case. Observers I and II reported them the same. Observer III held the weights a little looser in the lifting with attention but the lifting itself was the same. Observer IV raised the weights a little more

TABLE II

	No. of lifts	Ra L	Ra E	Ra H	Ta L	Ta E	Ta H	Rd L	Rd E	Rd H	Td L	Td E	Td H	Dif. a L	Dif. a E	Dif. a H	Dif. d L	Dif. d E	Dif. d H	a—d L	a—d E	a—d H
Obs. I	140	49	50	41	113	21	6	38	56	46	79	45	16	+64	-29	-35	+41	-11	-30	+23	-18	- 5
II	120	61	18	41	79	25	16	58	29	33	73	31	16	+18	+7	-25	+15	+2	-17	+3	+5	- 8
	260	111	54	95	187	47	26	107	69	84	176	51	23	+76	-7	-69	+69	-18	-51	+7	+11	-18
III	100	57	26	23	72	15	13	57	18	25	64	19	17	+21	-11	-10	+ 7	-8	-1	+14	-12	- 2
	220	93	62	65	171	28	21	98	58	64	160	41	19	+78	-34	-44	+62	-9	-45	+16	-17	+ 1
IV	100	21	33	46	49	32	19	36	28	36	52	32	16	+28	- 1	-27	+16	+4	-28	+12	- 5	- 7
	280	69	118	93	154	99	27	79	116	85	159	96	25	+85	-19	-66	+80	-20	-60	+ 5	+ 1	- 6

sharply and slightly higher "with distraction." This difference was too slight to be detected by the experimenter. Ob-

server IV was the only one who had any idea as to the purpose of the experiment, and he had surmised it.

Taking all facts into consideration it seems certain that with a training weight which gives a moderate *Einstellung* and original weights which are different enough in value to render discrimination easy, lifting the training weight with full attention produces a more intense *Einstellung* than lifting the same weight in the same manner, but with distraction.

3. *The Rôle of Consciousness in the Acquirement of Muscular Skill*

The third series of experiments was of a very simple character and useful chiefly in furnishing opportunity for introspection. It consisted in learning to throw balls at a target about eight feet in diameter, from a distance of 14 to 18 feet. Two university students of the psychological department served as observers. One, the writer, had almost no previous experience of the sort; the other, a gentleman, had thrown some, but "not enough to amount to anything." Ten throws were made in close succession, then a pause until the observer was rested, then ten more throws until fifty had been made. The experiment covered 16 days of 50 throws each, these days occurring, with few exceptions, in uninterrupted succession.

The experiment was not prolonged far enough to give a satisfactory learning-curve, such as has been found for similar work by other experimenters, *e. g.*, Bair, Book, Swift, and others, since general introspective results were the main object of our work. It may be said, however, that the greatest gain, both in uniformity and amount of score, came for each subject in the first few days.

In learning to throw at a target one must specialize and perfect certain elements of the complex mass of neuro-muscular co-ordinations of which he is in possession through inheritance and his own practice in general activities. His consciousness is taken up primarily with the target and the ball in his hand and vaguely with those particular and general bodily sensations which enter in to make up the "set" of the situation. Only gross errors, such as standing too far to the right or the left, or throwing with too great or too little force, are consciously corrected. The minuter, more skilful adjustments developed of themselves out of the larger, less perfect ones already existing, and were then perhaps consciously continued or avoided. Attention to the mechanical side of the throwing only resulted in inferior work; yet clear consciousness was necessary for good results, but it was consciousness of objective elements—the target and to a certain extent of the ball—rather than of

one's arm or its movements. After a little practice both observers mentioned the fact that greater concentration and fixation of attention on the target resulted in better throws. When greater effort consisted in deliberate attention to the *mark*, good throws resulted; but when, as occasionally happened, the observer tried to regulate the *process* and attended to the hand, arm, or ball, random shots were sure to occur. One observer remarked: "I don't believe thinking of the thing will do any good. All I can do is to stand before the target and *wish* to throw well;" the other said that he was simply trying to make good throws but did not know how he did it.

Good physiological condition, interest in the work and a tonic muscular condition seem to be concomitants of success, for when observers are ill they lack energy and interest, throw almost listlessly, and with poor results. On good days they stand erect with muscles tense and eyes fixed on the target and do their best work. One observer at such a time even found himself forcibly squeezing the ball. The amount of energy put forth grew more regular with practice, *i. e.*, there was better co-ordination.

The introspections show that, in such an almost purely sensory-muscular process, skill develops without consciousness of the details. The peripheral sensations accompanying or preceding the reaction contribute to form the background of consciousness and to produce feelings of satisfaction or dissatisfaction according as the movements are rightly or wrongly made. Consciousness has little place "as guide," save in the grosser features of the task, but attentive consciousness of the end was necessary for the development of these peripheral adjustments. Clear consciousness seemed to be accompanied by a general neuro-muscular tonicity favorable to the best work. Probably with clear consciousness the organism is acting more as a unit of closely knit parts, each of which is then more effective on every other part while it is active, than in a state of disintegration where association is loose.

4. Learning to Write in Unaccustomed Ways

The experiments of this series were, like the last, of a simple sort, though they involved skill of a somewhat greater complexity. They consisted in learning to write ordinary script with the left hand, and mirror script with both the right and left hands.

Left-hand Writing. In the normal script experiments eight observers assisted, four of whom were men and four women. All were trained psychologists, except one woman who, nevertheless, had had much practice as an observer and was

excellent at introspecting. One observer was almost ambidextrous, two were left-handed. No definite tests of mental type were made, but the indications are that two observers were, in this sort of work, predominantly motor.

The conditions of the experiment were kept as nearly constant as possible for each individual during all his work The experiment covered a period of about fourteen days. The standard sentence, written by all, was, "Motives are like chemicals. The more you analyze them the worse they smell." This the observer repeated several times before beginning to write in order to learn it. The sentence was written three times with the right hand with timing (with a stop watch); then once without, and three times with the left with timing and once without, with sufficient pauses between tests to avoid fatigue. It was explained to the observers beforehand that the timing was merely an incidental matter and that they should write at a convenient speed, merely writing each sentence continuously. After each sentence had been written, the observer was asked to give introspections as to methods used, points attended to, and any other items which might be of interest.

Inference as to the part "unconscious" factors play must rest partly on the fact that the observer fails to mention them and it is therefore open to the error of supposing that facts not remarked upon are unconscious, whereas the fault may be due to incomplete introspection or report. Yet it was impossible to ask definite questions as to position or methods, for then entirely unnoticed factors became clearly conscious and the subsequent course of procedure was apt to be changed. Exact objective measurements of improvement in writing are naturally, impossible, but must be judged in a rough way by greater uniformity in the slant and strength of the characters, and by their greater clearness and legibility.

The different observers manifested individual differences in their adaptation to the task, their methods of procedure and the speed and proficiency acquired; yet there are elements common to all. It is evident that easy and natural writing movements with the left hand cannot be made unless one assumes a position nearly symmetrical to the customary right-hand position and lets the hand take a free and uncramped movement. This will result in script with a "back hand" slant of a rather uniform character if one writes on a horizontal plane. It was to this position and writing that all observers tended, though they arrived at it in various ways and adopted it to different degrees.

Only three observers assumed an entirely symmetrical position from the start. Two of these, who were left-handed

observers, did so unconsciously, guided purely by the "feel" of the thing. The other observer analyzed the situation, discovered that this would be the proper way, and so took the position voluntarily. A fourth observer assumed a position almost symmetrical, and one which was little changed during the progress of the experiment. This he said he did "consciously and unconsciously," *i. e.*, semi-consciously. Of the remaining four observers all began with the paper in exactly the position used for the right hand, with the body turned at the same angle to the table and the left hand and arm twisted into an awkward position, the wrist cramped over to the right side of the body. With one observer the right hand held the paper at the upper left corner, taking the position which the left hand had always used, thus showing that each hand had changed places with the other.

All observers, save one, finally used some finger movements for the left hand, but only four began with them. Two of these were left-handed and one ambidextrous, and used the movements unconsciously. Observer V, who analyzed his position and assumed a symmetrical one consciously, used finger movements at first, but after the first sentence the natural tendency to use larger arm movements manifested itself, and the finger movements disappeared. One observer made them to get out of a difficulty and after that tried for them; another noticed her right hand carefully while writing, observed the finger movements, realized that skill could be obtained only if the finger movements were used in the left hand, and therefore consciously adopted them, but with considerable effort, and it was only when attention was directed to the hand that they were constantly made. Another observer "found finger movements coming of themselves" and continued them because the writing as a result was better, but even then they were hard to keep. Of the observers who did not use finger movements at the start, one adopted them on the second day, one on the fourth and one on the fifth. The only observers using finger movements naturally are those possessed at the start of some skill with the left hand.

Four observers went from a larger to a smaller hand, three to a slightly larger one, and for one, size remained about the same.

The large movements at the start may be due to one of two things. They may be the result of a general tensing up of all the muscles in the intense effort of the new occupation, and a general spread of energy over the whole body—a thing which could be observed in the tense muscles of the hand in five cases; in the digging and scraping of the pen in three cases; and in tension about the mouth, head-movements or

raising the heels from the floor, some of which were noticeable in all but the left-handed subjects. Or they may be due to the fact that the muscles involved in the larger movements have been trained in many daily occupations while the finer movements have been very little practiced. In the progress of the race one hand has been specialized for the more skilful work, the other hand (in most people, the left) being used far less. The left hand of an adult just learning to use it in left-hand writing, is in about the same condition as the right hand of a child who learns writing for the first time. The child's arm and hand have been used in larger activities, but the finer adjustments have not been practiced. When, therefore, the child and the adult begin the new task there is in both a general innervation of all the muscles and the larger movements are first made. The finer ones together with economy of energy appear later.

Writing in reversed slant appeared to a greater or less degree with all the subjects. In three cases the natural tendency was noticed in a few strokes and consciously continued; in two it was the result of letting the hand take its own position and "swing." Another tried to let the writing take its natural slant, which finally resulted in "back hand" script.

Improvement is characterized subjectively by a freeing of attention from the writing itself so that the observer is able to attend to details, to correct errors, and to make improvement in methods. Attention at first is so absorbed in the writing that the observer is not aware of his awkward methods. One by one he notices these and corrects them. Observers starting with good methods have fewer difficulties at the beginning and are able to anticipate them sooner. Attention is not only differently directed, but far narrower at the beginning than at the end of practice. As skill begins to develop, consciousness is wider and attention can shift from the task to extraneous matters with little disadvantage; where, as in the beginning, wandering of attention means distraction, and the work suffers. The relation, which exists between late and early conditions, exists also between the right and left-hand writing. In the latter, attention is easily disturbed; a strange pen, a slight illness, or a simple external hindrance have far more effect.

The general results of these tests with left-hand writing show the rôle of consciousness in learning of this kind to be corrective, its function being to criticise, to eliminate habits producing either physical discomfort or dissatisfaction with the product, and to make permanent any favorable variations which may chance to occur. The focus of consciousness

changes during the learning, attention at first being on the process itself, the details existing in consciousness only marginally or not at all. Later the learner attends to his methods and at the same time is more clearly aware of the elements leading to his satisfaction or dissatisfaction. As the methods are perfected they in turn become automatic, the learner assuming automatically the position which he has acquired consciously. As the process becomes still more automatic, attention wanders from it from time to time to foreign matters, without interference.

Mirror Script Experiments. Experiments in learning to write mirror script (that is, writing which begins at the right-hand side of the paper, and may be read by holding it up to a mirror or from the reversed side of the sheet) were carried on for a period of fourteen days with six observers, all of whom had served in the above mentioned left-hand experiments. The general conditions were the same as before. The subjects wrote the standard sentence three times with the right hand and three times with the left, and *vice versa* on alternate days, the writing of each sentence being timed as before except in two cases. No untimed tests were taken save in the case of two observers. As timing seemed to have no effect, untimed experiments were not made by the others.

The greatest difficulty was noticed by all observers in the first few trials, and consisted in knowing what the form of the letters should be. A certain amount of extraneous practice was allowed in order to meet this peculiar hindrance. Two observers began by writing on the blackboard with both hands at once, mirror script with the left hand and normal script with the right. This was easier than the writing with the pen, which required smaller movements. The other observers, seated at a desk with paper before them, were told to write the sentence in mirror script, after it had been explained to them what mirror script was, and were allowed to write the sentence, to hold the paper to the light and to correct mistakes.

Attention at the start was confined to the writing as a whole, but soon general difficulties decreased and particular ones were attended to, certain letter combinations being more difficult than others. After trying to make a letter of a certain more difficult form, the observers consciously chose a simpler style. As in the normal script experiments, excessive muscular tension was shown at first but later disappeared. With ease in writing, foreign ideas again begin to enter in every case; but attention cannot get too far from the process without disastrous results. One observer, for example, became so absorbed in a train of thought that he stopped writing. Ease of writing and freedom of attention, as before, allowed

difficulties to be anticipated and overcome before they were met. One observer consciously pronounced the difficult letters, because he found himself doing this in one instance with good results. Two observers visualized the movements, in difficult places, before making them. No observer mentioned attending to the process itself as a means to improvement, but two stated that attention to the process brought confusion.[1]

Had there been a good copy to give an idea of the letter forms, and had instruction been given as to position and relaxation of muscles in hand and arm, much of the difficulty would probably have been obviated.[2]

Learning to write, as evidenced in the above experiments, depends on consciousness mainly for perfection of methods. Adjustments which are at first "unconscious" become highly conscious then later automatic, a great degree of perfection requiring the third stage — automaticity. It is only as the grosser elements become automatic that attention is free to consider the finer ones.

A certain degree of difficulty is necessary to interest. As the task becomes automatic and easy, it is impossible to keep foreign ideas out of mind.

Progress is from coarse to finer muscular adjustments, and from larger to finer writing in most cases. This means a specialization of the smaller finger and hand movements, and a saving in energy, since less exertion is needed to call these into use, than for the larger arm movements.

Progress may take place without a high degree of consciousness, yet it will not go so far nor proceed so rapidly as when there is consciousness of the process itself.

5. *Learning to Multiply large Numbers Mentally*

The experiments of this series consisted in learning to square three-place numbers mentally, and were suggested by recent work of Thorndike in multiplying mentally a three-

[1]The matter of increased speed in the writing does not especially concern us here, though the records were kept and tabulated. It may be mentioned in passing, however, that there was very often to be observed an increase in speed in the left-hand writing, in the mirror script and even in the normal writing with the right hand, from the first to the third executions of the standard sentence in a single test—a transient gain in skill by practice of a particular set of movements.

[2]In any instruction it is just this which should be the function of the teacher, *i. e.*, to provide good methods and to call attention to errors which the narrow attention of the learner will not enable him to see. In a task like writing much mechanical repetition is needed; yet repetition without attention will not result in improvement but merely in the strengthening of abilities then possessed, and even of awkward procedures.

place number by a three-place number.[1] He found in the 33 observers who did from 28 to 96 examples of that sort, a gain of over 50 per cent. in skill, but gives no introspective results, except that strength of visual imagery was not responsible for the improvement, and that more individuals reported decrease than increase of visual imagery. My own experiments were carried out in a manner similar to his, except that for simplicity's sake my observers squared one number instead of multiplying two different numbers together. This made it necessary to hold but three digits in mind at the start, instead of six. In making the number list, digits above two were written on cards and drawn at random from a box. If a number contained the same two digits as the number before it, it was given a later place in the list, in order to avoid the distraction, or aid, of too great similarity.

The manner of conducting the experiment was as follows: A number was read to the subject, the observer repeated it, and the stop-watch was started. When he finished the example he gave the result, the watch was stopped and the time recorded. In the first day's trials the observer was asked to work aloud, but in some cases this proved a distraction and was not required later, though those who wished to work aloud were permitted to do so. In reckoning the results Thorndike's arbitrary method of transmuting errors into time by adding to the watch time one-tenth of its amount for each error made, was used.

Preliminary tests consisting in running through the forty-nine two-place numbers possible from combinations of digits above the digit three were carried out with two observers, and took six and five days respectively. In this short time great improvement was made; for observer A the average daily score in seconds for each multiplication was 51.1, 40.1, 35, 43.1, 41.9, 30.6, and for B, 81.7, 29.1, 26.2, 16.3, 21.4. (B's last score was raised by one exceptionally long time where the example was worked twice. If this one case be left out the last score is 16.2.)

Introspection showed that the gain was partly the result of the refreshing of the mathematical associations, *i. e.*, practice in multiplying and adding, but far more, of choosing and using new methods to avoid obvious difficulties, and of improvement of methods already in use. Ideas as to means of improvement were not the result of analysis previous to work, but came after some practical experience, when the observer was oriented and realized his deficiencies. The formulation of

[1]Thorndike: The Effect of Practice in the Case of a Purely Intellectual Function, *Am. Jour. Psy.*, XIX, 1908, 374-384.

such improved procedures was really a process of generalization. When the same peculiarity occurred several times, the observer recognized its universal character spontaneously, and not as the result of conscious search after it. The common element seemed to drop out of itself. Then, because of his strong desire for improvement, he consciously made use of it; but had he not been alert, it might easily have escaped his notice, and have been of no profit to him in his progress.

Instances of this process are the following: After a few examples *A* realized that, with the numbers in use, the answer must always have four digits. Visualization for this observer was at first impossible, the whole process having to be carried on in auditory-motor terms. The two partial products were retained as a sound whole; and to get the separate digits for the addition the observer must run through these products several times till the required digit was found. After several such experiences she realized that it was only in an auditory-motor way that work could be done, so in adding, she repeated the first partial product through as far as the units digit, held that in mind as the units digit of the complete product, repeated the first partial product again as far as the third digit from the left and the second partial product as far as its final digit, added these two and placed them in the tens place of the complete product, and so on. Later, visualization increased to some extent as the result of extreme effort, but remained almost entirely visualization of a special "form" into which the digits were fitted as they were required. After practice in addition, it was noticed that the first digit from the left of the second partial product and the last of the first partial product had no digits above or below them to add to them; and consciously less attention was given to them and more to the other four digits. Again, having worked slowly and deliberately so that one partial product escaped her by the time the other was obtained, she worked more rapidly in subsequent multiplications, spending more time repeating and emphasizing the results.

Observer *B* worked a single day, multiplying the numbers out by full multiplication. He then served as experimenter, with *A* as observer, and while so doing realized that the binomial method might be used, and used it in going over *A*'s work. In his next work as observer the change of method reduced his record from 81 to 29. The process was first as follows: Required to square 35. $a^2 + 2ab + b^2$, $35^2 = (30 + 5)^2 = 30^2 + 2.30.5 + 5^2$. Later he noticed that a^2 always ended in two zeros and simplified the process by simply setting together a^2 and b^2 then adding $2ab$. Then the method unconsciously came of getting $2ab$ while repeating $a^2 + b^2$, was recognized as a method and continued. Later, while making notes, it occurred to him that in multiples of numbers ending in 5, $2ab$ will be the first digit $\times$ 100. This was then consciously used with success. Superfluous words fall away in the process, only numerical results being given. This last was unconscious, however, as to intent. In all such work, a rule which is first conscious becomes an unconscious habit.

In squaring three-place numbers six persons served as observers, three men and three women, all of whom were university students. Observer V is the same as observer *A* of the two-place number experiments. The observers were practiced for two days on two-place numbers and three-place numbers, each subject working three three-place problems before the regular experiments began. The results included in the tables are only those of the regular experiments. The rec-

ords are based on the fifty examples worked by each subject, and cover between ten and fifteen days. Each worked half an hour a day. The method of timing was that described above for the two-place numbers. A rest of from two to five minutes between problems was given. If the original number was forgotten in the midst of the work, that problem was given up, and after a rest, a new one taken. As the observers worked at different rates, and as some forgot more numbers than others, the number of days taken varies. The following tables give the average results in errors, time and combined result for the six observers.

A decided gain is clear as far as speed is concerned, though accuracy seems to remain about the same, unless in the case of observer IV, where there is slight improvement. This, however, may be a matter of chance. The accuracy corresponds to one's skill with the addition and multiplication tables, which have been so much practiced that they have reached a "plateau stage" where no further improvement is likely. Improvement, in this experiment, is not in accuracy of work, not in the speed of computing (at least not to an observable extent) but in the ability to hold more things in mind and to attack the work directly and with more advantageous methods. The asterisks in the table indicate the points at which new methods were introduced. An asterisk occurring before the first day's score indicates that a method of work peculiar to the observer was developed in the preliminary three-place examples. Observer VI began the first day's regular experiments with a method which required the retention of but a few numbers at a time and made use of no new method. Observers I, II, IV had developed methods before this day, but made improvements in them during the progress of the experiment. It will be noticed that introduction of new methods resulted in a large drop in the time, except in the case of observer IV, who did not continue methods used after they were once developed, except the general method used on the first day.

The most difficult part of squaring three-place numbers by full multiplication was found, by all observers, to be the retention of the partial products long enough to add them, and to add the proper digits together. As they were allowed to work in any way they chose, the effort of each was to find some way to lessen this difficulty. Visualizers, as might be expected, had less difficulty than observers with little visual imagery. A brief account of the procedure of each of the six observers will best show the methods of improvement. Fatigue or distraction made retention difficult for all the observers and affected chiefly that part of the work.

TABLE III

Obs. I	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Errors	2.	.5	.6	.3	.25	.6	1.	.6	.5	1.6	1.2	1.	.6	1.0	1.0
Time	420.5	252.5	162.6	263.3	197.7	149.9	112.1	127.6	85.5	130.9	105.7	72.2	103.6	120.9	116.1
Comb.	504.1	265.7 *	173.4	269.	202.6 *	159.9	123.3	136.1	89.6	152.7	118.4	81.2	109.8	132.9	127.6

Obs. II	1	2	3	4	5	6	7	8	9	10	11	12
Errors	3.3	1.5	1.3	5.2	2.0	1.5	2.0	1.4	2.5	1.8	3.0	1.6
Time	102.7	140.3	113.5	98.3	71.6	78.7	86.9	87.1	104.7	81.4	60.8	52.3
Comb. *	136.5	165.8	128.6	174.9	85.9 *	90.5	91.3	99.3	130.8	96.0	76.5	60.6

Obs. III	1	2	3	4	5	6	7	8	9	10	11	12
Errors	3.	2.6	3.2	2.0	2.5	.6	1.8	1.6	2	1.6	1.4	1.2
Time	178.2	128.6	145.7	149.2	169.7	167.2	112.	134.4	145.8	124.3	127.8	108.
Comb. *	231.8	162.8 *	193.1	179.0 *	212.1	177.3	132.2	155.9 *	175	155.4 *	145.6	109.4

TABLE III (*Continued*)

Obs. IV	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Errors	1.3	1.3	1.0	1.3	.7	0	1	1	.4	.6	1.2	.6	2.	3.
Time	325.9	263.1	399.6	246.0	325.2	313.6	254.9	172.3	180.4	184.9	199.6	191.7	168.8	161.6
Comb.	369.4	271.1	439.6	278.8	349.8	313.6 *	263.4	187.3	187.6	196.0	227.1	204.5	202.6	210.0

Obs. V	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Errors	2.0	2.0	1.3	1.0	2.	1.3	1.0	2.0	1.6	2.0	1.0	2.6	2.5	2.0
Time	332.9	409.3	304.5	333.5	285.1	222.6	206.8	157.7	219.0	152.6	240.0	242.9	151.1	177.7
Comb. *	399.5	487.9	345.1	366.8 *	342.1	252.4 *	227.5	189.0	163.8 *	182.9	264 0	307.6	188.9	210.0

Obs. VI	1	2	3	4	5	6	7	8	9	10	11
Errors	4.0	1.5	1.6	2.0	1.1	1.5	1.0	1.0	1.0	1.2	1.3
Time	96.7	60.2	67.1	59.7	42.1	39.3	51.5	37.3	46.5	44.9	37.8
Comb. *	132.1	69.2	77.8	71.7	46.9	43.3	56.6	41.0	51.2	50.5	42.8

Observer I. This subject possessed no visual imagery for this sort of work. By the second example of the preliminary practice, he was consciously repeating the first partial product to the last digit, setting this in the answer; then the third digit of the first and the last of the second were obtained in the same manner and added, etc. As the required figures were taken out and embodied in the sum they were forgotten. The next day he tried to add two columns at once. On the day before the regular experiment he was permitted to make writing movements with his pencil, which he did henceforth, finding it an advantage. On the second day of the regular tests he tried remembering the numbers by pairs. (Notice the decrease on this day from 504.1 to 265.7.) On the fifth day the very advantageous idea of adding the first two partial products and adding the third to their sum was hit upon, thus having at no time more than two numbers to keep in mind. After this the drop is decided. The increase in time in the last three days was due to fatigue from other work earlier in the day.

Observer II. This observer is a good visualizer and has had experience in teaching mathematics. On the first day the observer tried to square two numbers, but did not succeed in either case, and refused to work. The next morning while thinking of other things, a method occurred to her, which she used with success throughout the work. It was to multiply the number by the multiple of a hundred which stood nearest, then by the hundreds digit multiplied by ten, and adding or subtracting the result, according as the first multiplier was below or above the original number, then multiplying by the units digit and adding or subtracting. Thus only two sets of numbers had to be retained and work was considerably in ciphers. For the first two days of the regular experiment a few seconds were taken to think out the method of work, but later this became unnecessary and the problem was attacked directly. The method had grown automatic. On the fifth day a permanent modification occurred in adding or subtracting by thousands, tens, and units visually. A question by the experimenter as to the way the work had been done suggested this.

Observer III—A visualizer. The first three-place number was declared to be "terrible," the greatest difficulty being to retain and add the partial products. In the second example she added the first two partial products and then the third. The next day the method was improved further, conciously, by getting the sum of the first two partial products before multiplying for the third. The regular experiments were begun with this method, which was afterward modified but slightly. The modifications were as follows: "putting" the first partial product on all the four fingers of the left hand and the second on all but the little finger and including the sum. This resulted in the thumb and little finger having only one digit, and the others two; this method was not continued. The third partial product was "put" spatially above the sum of the first two on the fourth day. On the eighth day she "put the first sum in the left ear" and got it again when needed. From the first, the observer automatically made writing movements on the table to accompany her work.

Observer IV (no visual imagery for this sort of thing). The observer developed no method until the sixth day except the repetition of the partial products until he came to the digit required for the addition, as described for observer I. He consciously hurried through the process of multiplication in order to spend the time on repetition and emphasis of the result. Notice the decided decrease in the score after the sixth day when the new method was taken by adding the figures as soon as they were obtained instead of first multiplying for each partial product. Subjectively the work was much easier after this way was taken.

Observer V (the writer, little visualization for this sort of work). The method of observer III, namely, the addition of the first two partial products was deliberately borrowed and used in the first day's work. The

calculation was consciously made as rapidly as possible that the parts might not be forgotten before the whole had been secured. On the fourth day the last two digits of the first sum were discarded leaving only a three-place number to add. Figures when they were required for addition were fitted into a visual "number-form" which had unconsciously developed. On the sixth and eighth days new methods were tried which worked well at the time, but were used only on that occasion. The first was to add the first and third products first, the second to place the digits on the fingers of each hand and set in proper juxtaposition. It was evidently forgotten. Two column addition was consciously tried and used in instances when the numbers to handle were not too large.

Observer VI. This subject developed his method in the practice tests and did not change it; improvement for him therefore consisted in practice in the use of his method. It was to break the number up into two numbers, the first consisting of the hundreds and tens and the last of the units, and to use the binomial method of squaring; in obtaining the square of the first (two-place) number, the a^2, the binomial formula was also used. This method occurred to the subject after he had gone to bed on the first day of squaring a three-place number by full multiplication, and he considered it an original method until several days later a distinct visual image of his old arithmetic book with its thumb-worn page bearing an illustration of a formula similar to this for extracting the square root, flashed up before him. Part of the original experience, without its localization in time or place, had been recalled, and given him what he considered an original idea. Stronger stimulation of the complex brought it back in all its original setting. By the third day introspection shows less attention and strain than at first, the method had become spontaneous and it was easier to keep two different sets of numbers in mind. Practice had resulted in a widening of the field of consciousness. The sixth day the observer said the work was easier because he got his results almost at a glance and when they came he saw the figures under the ones to which they should be added. When he added a certain column he saw only these figures distinctly; the others were hazy, but he could call them up when he wanted them.

At the close of the experiment, each observer was asked to give a report as to what he thought his improvement had consisted in, what part of the processes was conscious and what unconscious. All said the task was easier at the close than at first. Observer II, who developed a very simple method at first, said that after the first few days she was conscious of little improvement. Three observers attribute most of their improvement to the adoption of an easier method, and three assigned "practice" a large place. For all, the calculation itself was a highly conscious affair, though for three, the results sometimes seemed to come spontaneously. Adoption of new methods was in every case clearly conscious, and not from falling into a certain habit, noticing, and continuing it, as was the case in the target throwing and the writing. Very slight suggestions from one's own work or from outside were often responsible for the idea of the new way of working, or it "just popped in" as one observer stated. However it came, the idea had to be there to effect the change. After the method was practiced a little, it was used directly and with-

out thought. "Unconscious" improvement came in the widening of the conscious field, adaptation to the experiment and the like, so that the feeling of strangeness and awkwardness disappeared. What at first seemed an impossible task no longer looked so when one became oriented. Possibly another "unconscious" factor was the gain in speed in making computations as the result of greater familiarity with, or rather, refreshing of, the addition and multiplication tables. Mere practice caused improvement in the use of methods consciously adopted.

6. *Results of the Last Three Series of Experiments*

The results of the last three series of experiments seem to agree in showing that the function of consciousness in learning is to improve the process by bringing errors to light and correcting them, and by adopting improved methods suggested by some habit fallen into, or by some idea as to better possibilities. The more purely muscular the process to be learned, the less conscious the learning of it. In the target throwing improved methods of throwing came about of themselves and were not noticed until later. Attention to the mechanism only resulted in disaster. The most one could do consciously was to attend closely to the bull's-eye and throw, the proper co-ordinations seeming to take place of themselves; gross errors only were consciously corrected. In the writing experiments, consciousness played a greater rôle in supervising and correcting the process, and for some observers in starting an advantageous method. In the intellectual task of squaring a three-place number every decided step in advance was the result of a conscious change.

But these three grades of learning all showed "unconscious" improvement as the result of repetition (even the arithmetical computations), improvement which was entirely at the physiological level. Improvement, therefore, does take place without the control of consciousness. Yet even at the grade of learning where this is the truest, we cannot say that one is unconscious, but perhaps rather that marginal awareness, in the sense of organic and peripheral sensations, and feelings of satisfaction and dissatisfaction, is always present and affects the result. It is, one may conjecture, a feeling of dim awareness akin to this unanalyzable, undifferentiated state which accompanies the learning of animals low in the scale. That it *directs* the learning is at least not certain, if one reasons by analogy from human learning where only the higher, more specialized acts are under conscious control. The simpler and more "muscular" the learning, the more vague and

indefinite the subjective accompaniment. Practice alone is the improving factor. In more complex processes like writing the learner is able to assume an objective attitude and direct and criticise his own activities and to shorten, by choosing new methods or avoiding observable mistakes, a process which would otherwise require much mechanical repetition. In still higher operations, like arithmetical calculations, consciousness of the process is still clearer. It acts vicariously for practice, which takes a subordinate rôle. The rôle of consciousness is similar to that of the teacher who can do little for one learning feats of muscular skill save give a few simple instructions, leaving the rest for the pupil to get by the hit and miss of practice; but in more complex activities he can act as a pattern, giving methods and pointing out deviations from them. Since right methods and easier work result in a widening of consciousness, this will leave the pupil's attention free for still further advances.

SUMMARY

In Part I we have considered consciousness as an ultimate fact, undefinable, identical with awareness. Unconsciousness denotes for us its opposite— entire absence of awareness, that which is entirely outside of our experience at any moment of time. Subconsciousness, for which we prefer to substitute "perceptual" factors, gives focal consciousness its qualitative character. Subconsciousness is *consciousness* of a less distinct degree. Divided consciousness, such as is present in cases of multiple personality, is best called "co-consciousness."

The question of the existence of "unconscious psychic processes," *i. e.*, psychic accompaniments of physiological processes lacking awareness, depends for its answer on one's metaphysical concepts, which are in the end a purely temperamental matter. Denying them leads to the interactionist position. Throughgoing psychophysical parallelism demands the assumption of psychic factors accompanying physiological changes, and this position we have taken, insisting, however, that such "psychic" processes are qualitatively different from anything which enters into consciousness. According to such a view one may speak of physiological processes in addition to "unconscious psychic processes."

We have incidentally reviewed the arguments *pro* and *con* as to the presence of "unconscious" factors and their influence on mental phenomena. Our main interest was, however, in the relation of consciousness to learning. From general observation we have seen no case of learning where one is absolutely unconscious, yet one may be unconscious of the

end, the process and even of the development of the habit or association itself.

Our own experimental results are the following:

1. Our experiments on the nonsense-syllable material give chiefly negative results, but justify, so far as the conditions of the experiment permit, an inference that what is entirely outside of consciousness, though it is in such a position that it might easily become conscious, has no great effect, positive or negative, on the learning of the same material when it is presented later to clear attentive consciousness.

2. In the experiments on the "Motor Set" (*Motorische Einstellung*) we find that a habit may be formed despite the fact that one is unconscious that one is forming it. Yet, withal, attention to the task produces in all cases a more definite habit, a stronger "*Einstellung*," than that which is caused when one is almost unconscious of his performance. Attentive consciousness without doubt is accompanied by greater tension in the particular muscles involved in the current activity of the organism and in their nervous connections. Here activity is concentrated. The more fully the physiological mechanism is thus put into activity the more it is affected in the direction of easier and more efficient activity of the same sort.

3. The experiments on throwing at a target involved learning of a sensory-motor kind, the doing of a definite thing: it was practice with a fixed aim in view. Here focal consciousness was almost entirely projected on the target, the ball and hand occupying a peripheral place. Conscious control was exercised only over the grosser parts of the process. Methods gradually changed, and improvement appeared, without conscious change or control. The sensations from the arm and body no doubt contributed to the improvement, but these were always at the "perceptual" level and consisted rather of an undifferentiated background.

4. In the writing experiments conscious direction of the process and methods was more marked. At first consciousness is bound down to the general execution of the task. The more general, larger elements, becoming automatic, leave consciousness free to turn to details, when disadvantageous methods are noticed one by one and eliminated. Unconsciously modifications in the method crop out, and as consciousness becomes freed from details these are noticed, practiced, and improved upon. This sometimes results in a considerable change of adjustment of the different factors.

5. In the experiments on mental multiplication consciousness had a more immediate effect than in the more "muscular" sorts of learning. Here advantageous methods occurred to the

subjects while they were working, or between the experiments, and when these were adopted the improvement was immediate and permanent, whereas in the more "muscular" sorts of learning one's muscular co-ordinations had to be practiced somewhat before the new method was perfected. In the number experiments, just because one is alive to the situation, he notices clumsy methods and slight errors, and is therefore ready to improve upon them. After a method was consciously developed, however, it was soon used unreflectingly—it became a habit. In proportion as an activity is conscious, consciousness is an aid or even an essential factor in its acquisition. This applies to details and part-processes as well as to the larger units of activities.

Conclusions

In conclusion we may say that in learning of any sort both conscious and unconscious factors exist. Unconscious factors are those involved in the fixing of the association by practice, and the cropping out of modifications of behavior subsequently utilized by consciousness.

The more intellectual and highly conscious the material to be learned, the more direct and immediate the effect of conscious control. Practice results in a standing out of common features of the process; these are focalized, and generalized into rules for new and better procedure, which immediately takes place.

In complex processes involving both an intellectual and a muscular side, the activity as a *whole* is conscious. Details are gradually mechanized, leaving attention free to attack new difficulties. Factors of the activity which are at first only at the "perceptual" level become clearly conscious, are then practiced and improved upon, and finally become mechanized and unconscious again. Consciousness is a corrective agent, eliminating errors, improving on elements unconsciously developed, and organizing the whole procedure.

In learning simple muscular co-ordinations consciousness is focussed entirely on the end—on the outcome of the movement. One is only dimly aware of the different sensations and feelings entering into his bodily adjustment, and should any of these become the object of attention, disturbance of co-ordination results.

Learning can progress, however, without consciousness of the end or of the fact that one is learning, but even here a high degree of attention to one's task brings more marked results than work under distraction.

So far as our experiments go, factors never entering consciousness have neither a beneficial nor hindering effect on the learning.[1]

[1]The writer wishes to express her obligation for the faithful service of those who served as observers in the above experiments, and particularly to Dr. E. C. Sanford, in whose laboratory the work was done and at whose suggestion the subject was begun.

APPENDIX

Experiments with Meaningless Syllables

The general plan of these experiments has already been described in the body of the paper (pp 179 ff). It is only necessary here to record the details of procedure. The work was done with twelve-syllable series of meaningless syllables prepared in accordance with the method of Müller and Schumann's *"verschärft normal"* series,[1] except that additional letters were used to increase the possible number of syllables and to adapt them to English speaking observers familiar with German. There were 20 initial consonants and double consonants, (b, d, f, g, h, j, k, l, m, n, p, r, s, t, v, w, z, th, sh, ch), 19 finals, (b, d, f, g, j, k, l, m, v, p, r, s, t, v, x, z, th, sh, ch) and 14 vowels and diphthongs (a, e, i, o, u, y, ä, ö, ü, ai, oi, ee, oo, ou).[2] These syllables were presented by means of a rotating drum of the intermittent-movement type, manufactured by Spindler and Hoyer of Göttingen, which permitted the syllables to remain at rest during the greater part of the time of their exposure. (See Fig. II which shows the apparatus from the back and side.) The syllables were seen through the opening of a suitable screen (See Fig. III) in such fashion that a single syllable of the series to be learned appeared each time between two syllables of series with which at the moment the observer had nothing to do. Thus the syllables

tam pog bex

would be shown, the observer being required to learn the middle series to which *pog* belongs, but having nothing to do at the time with the series to which *tam* and *bex* belong.

The observer sat before the screen and read the syllables of the middle series as they appeared through the slit. The experimenter sat at the side of the machine to the observer's right, his movements being entirely concealed from the latter by a large screen of gray cardboard. Directly in front of the apparatus and resting on the same table was a second drum, a portion of the surface of which could be seen through a slit in the black cardboard screen before it. (See Fig. III.) The syllables were all learned by the "Treffer method," and the "Treffer syllables" were shown on this drum, which was turned by the subject as the syllables were required.

The syllables to be learned were written on strips of white paper 12½ x 3 inches, ruled with fourteen lines and so proportioned to the drum, that after one complete presentation of the series, two blank spaces were shown before the first syllable of the series reappeared. The odd numbered members of the series—the "Treffer syllables"—were also written on strips 10½ x 3 inches to fit the smaller drum.

The experiments fell into three series, *A*, *B*, and *C*, and were carried out with two trained observers *S* and *E*.

[1] Müller u. Schumann: Experimentelle Beiträge zur Untersuchung des Gedächtnisses, *Zeit. f. Psych.*, VI, 1893-94, 106.

[2] The series were prepared throughout the greater part of the work by a competent assistant not otherwise connected with the experiment.

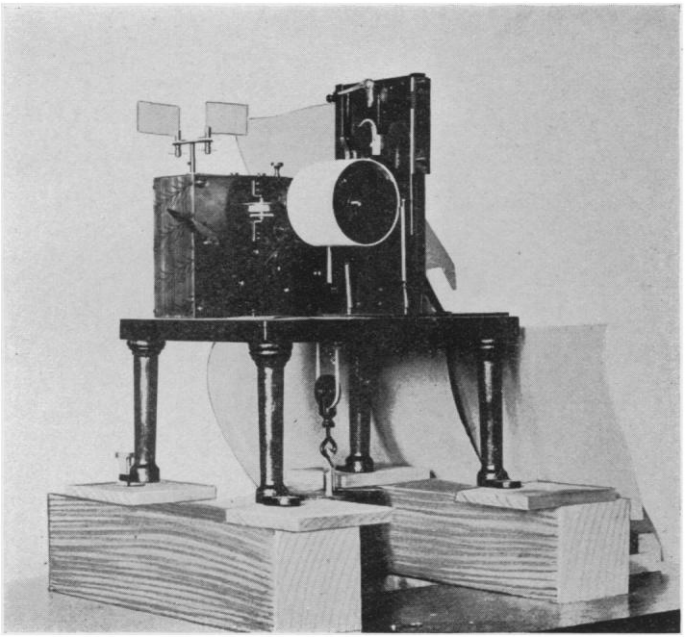

Fig. II

Experiment A. Problem: If a series of syllables is presented within the range of clear vision alongside of a second series which is to be learned, and engages the observer's attention, to find whether such a side series to which no especial attention has been given will later be more easily learned because of its exposure to possible "unconscious" perception. If Sidis's and Scripture's experiments are valid in their results, it was judged that we should find evidence of "subconscious" learning in the more ready memorizing of series which have been so exposed.

Three of the above mentioned twelve-syllable series were written in three vertical columns, so that the first syllable of each series appeared to the observer through the slit at the same time, then, as the drum turned, the second syllable of the three series together, and so on to the end. These series we shall call *a, b, c,* reading from left to right, *b* being the middle series, and the one learned.[1] On a second strip were written three series, *d, a, e; d* and *e* being entirely new series and *a,* the one which had stood to the left of *b,* the first series learned. On a third strip was written an entirely new set of three series, *f, g, h;* on a fourth strip, *i, h, j,* of which *h* had stood to the right of *g,* the series previously learned. All ten of these series were *"verschärft"* series, and the ten together constituted a regular set.

The number of series which could be used for each subject was, from the nature of the case, limited (11 sets for *S* and 12 for *E*). The method of obtaining syllables enough for all the experiments and avoiding familiarity with the syllables as much as possible was this. Syllable series which had been side syllables for *E,* but not learned (there were 6 such in every set), were transposed so that they occupied the places of *b, a, g* and *h* which had been learned, and were then given to *S,* and *vice versa.* Thus, if series retained their former lettering they would read *j, i, h; g, j, f; e, d, c; b, c, a.* After each subject had learned these transformed series, *E.* was given the transformed series for *S,* and *S* for *E.* Then each was given the series the other had learned first, but the syllables of the individual series were shifted. This made a possibility of 552 new syllables for each subject. When these had been run through, the second and third permutation (which the subject had learned before) was repeated.

An extra series (indicated in what follows by *x*) was also used each day and was obtained by taking a strip from an unused set and learning the middle series. One set thus divided furnished extra series for four days. This extra series was given sometimes first, sometimes third and sometimes fifth in the order of the day, each subject being kept in ignorance of its position, so that he was never aware of which series he was learning. The order which was maintained for the learning was, therefore, either: *x, b, a, g, h;* or *b, a, x, g, h;* or *b, a, g, h, x.*

The odd numbered syllables of the middle series of each strip were written in the centre of a slip fitting the "Treffer" drum; here, therefore, there appeared through the slit only one syllable at a time instead of three. For the first three days, the "Treffer" order was given according to the permutations of Müller and Pilzecker[2] but afterwards the "Treffer" syllables were written in a direct order from one to eleven, as it was decided that a varied scheme would give less uniform results with a moderate number of experiments, and would not in any case influence the point at issue in the experiment.

The average time taken for ten revolutions of the drum during the practice work and for two days of regular work was 87.1 seconds for ten revolutions or 0.62 + seconds per syllable. This speed was accelerated on March 10 (the third day), and from then on was 80.2 sec. per 10 revolutions or 0.57 + second per single syllable.

[1] The middle series is always the one learned in these experiments.

[2] Müller u. Pilzecker: Experimentelle Beiträge zur Lehre vom Gedächtniss, *Zeit. f. Psych.* Erg. Bd. I, 1900.

Each observer served as experimenter when the other was observer. Both knew the object of the experiment, but neither knew the results until the experiment was finished, as no accounts were cast until the end. With the exception of the first two days of regular experimentation, when *E.* worked at 2 P. M., *E.* served as subject from 8 until 9 A. M. and *S.* from 12 to 1 P. M. (The time for *E.* was changed because syllables which *S.* had recited at 12 persisted and acted as a disturbing factor.)

From January 24, 1909, to March 7 practice work was carried on every day except Sunday and four days of the Easter Vacation. Regular work began March 8 and was carried on every day except Sunday and one day when *S.* was out of town and another day for *E.* when the machine was out of order, making 25 days of regular work for *S.* and 24 for *E.*

At the words "In your place" the observer took his seat before the machine. This was started and the drum allowed to make one revolution to get its speed; as the first blank space appeared the experimenter called "ready," and lowered a shutter previously hiding the drum. The observer began to read as soon as the first syllable appeared, reading through the whole series of twelve syllables. After the two blank spaces had passed the series was read through again, and so on, until it had been repeated twelve times. The syllables were read pair-wise, at first in trochaic rhythm; later both observers fell into the iambic. When the last syllable was read on the twelfth revolution, the experimenter raised the shutter and started a stop watch. The observer began immediately to turn the "Treffer" drum, which was adjusted so that a single blank space preceded the first "Treffer" syllable, and read each "Treffer" syllable as it came up, giving, if possible, its associated syllable (*i. e.*, the syllable which had formed the other half of the pair); when he could not recall a syllable he said "don't know" and passed on to the next. When the last associated syllable had been given (or given up) the stop watch was stopped. This made a somewhat rough method of timing, but was effective enough for this experiment in which time was only a minor consideration. The observer was neither hindered nor helped by the fact that he was being timed. A list of each series to be learned had previously been written in a blank book and opposite each syllable was placed a check mark, if the correct syllable were given, a dash if none came, or the syllable which was given if a wrong one was given. After testing his associations with the "Treffer" syllables the observer's introspections were taken on such items as the difficulty of the series, the conditions of his attention, and influences which might have favored or been disadvantageous to the learning or reproducing of the series. The whole process—repeating the series, giving the associated syllables and the introspections—took, on an average, two and a half minutes. Ten minutes after the first series was begun, the experimenter again called, "In your place," and began the second series by starting the drum and, at a ready signal, letting down the shutter. Between the learnings a free time of about seven and a half minutes elapsed. In this interval the observer was allowed to relax as he pleased, either in looking over books, walking around the room, or gazing out of the window. But any taxing occupation which absorbed the attention to a considerable degree was avoided as it was found to have an unfavorable effect on succeeding series.

In computing the results a unit was allowed for each perfect syllable, 6 therefore being the score for a perfect record, *i. e.*, the recall of each of the six even numbered syllables. An average was taken for each of the series for the whole period of the experiment (24-25 days). A modified average was also made in order to include partial successes as follows: One-third was given for each vowel, diphthong, consonant or double consonant correctly given. Thus a syllable having only the vowel correct would score $\frac{1}{3}$ and one having its two consonants or a consonant and the vowels, $\frac{2}{3}$.

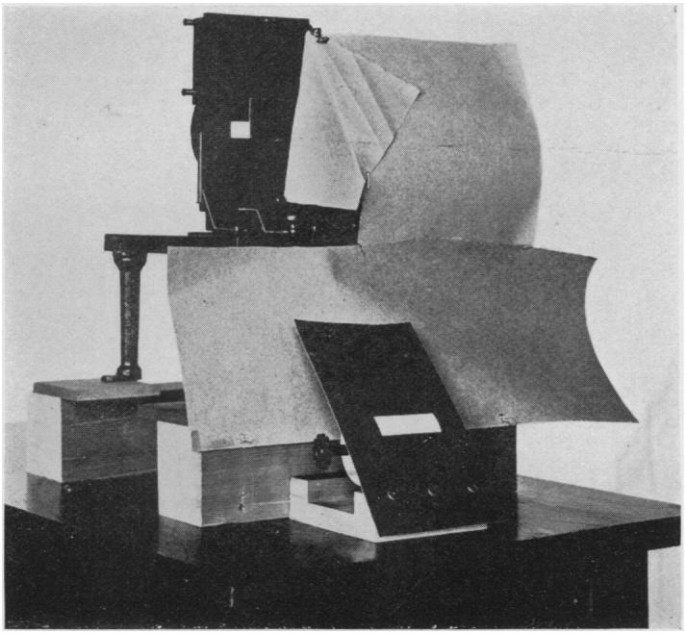

Fig. III.

Fig. III. In this figure the screen of the upper drum is arranged to show but a single syllable, an arrangement used in Experiments *B* and *C* below. In Experiment *A* it was open full width horizontally and showed three syllables at a time. The treffer drum is seen below behind the black cardboard screen.

The average of these results gives the modified average. Stated in tabular form the results are as follows: The figures in parentheses stand for the averages reckoned from perfect syllables only, and those standing free, for the modified averages.

TABLE I

Series	b	(P. E.)	a	(P. E.)	g	P. E.	h	P. E.	x	P. E.
Obs. S	(2.62)	± .21	(3.05)	± .19	(2.86)	± .12	(2.86)	± .12	(2.91)	± .18
	3.12		3.21		3.24		3.19		3.34	
E	(3.28)	± .13	(3.09)	± .17	(2.42)	± .16	(2.86)	± .19	(2.84)	± .15
	3.55		3.33		3.00		3.00		3.28	

For observer *S* the *a* series has a slight advantage over the *b* series, but the *P. E.* is so large that its advantage is quite uncertain. The *h* series is inferior to the *g* series. Taking account of subjective conditions we find that the *a* series was on the average learned under more favorable circum-

stances than the *b* series, and the *g* series than the *h* series; *i. e.*, there were more "mnemonics," the syllables were easier, or attentive conditions were better. For *E* the *a* series is poorer on the average than the *b* series, but the *h* series is better than the *g* series, if only perfect syllables are considered; if the modified averages are compared the two are equal. Here subjective conditions are slightly in favor of the *g* series. We may therefore infer from the results of both observers that the mere fact of having been shown as a side series does not favor that series when that series itself is to be learned—at least not to a degree sufficient to be detected by this method of experimentation.

If we arrange the averages of each series according to the position it occupied in the day's programme we have the following table:

TABLE II

	Observer *S*					Observer *E*				
Place in day's programme	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
X	3.2		3.		2.5	3.0		2.9		2.8
B	2.8	2.3				3.37	3.			
A		2.9	3.25				3.19	2.6		
G			3.3	2.68				2.43	2.42	
H				3.3	2.75				3.29	2.77
Average	3.0	2.6	3.18	2.99	2.62	3.18	3.09	2.64	2.85	2.80

The figures on the first line, reading across, denote the place in the day's work; the first column gives the name of the series. The partial successes are included in the figures used for this table. These figures show that when series of a certain denomination come early, they almost without exception show better results than when they occupy a later place in the experiment, and there is also a tendency to a general decrease from the first to fifth place as the X series and the averages show. We find a slight exception for *S*, where there is a rise for the third series of the set after a low score for the second series. Subjective conditions probably account for the increase here. What we had therefore in Table I is probably only the result of this general tendency.

Experiment B was next undertaken. The problem was to find whether a side series actually read a single time with full attention would be learned more readily for that fact, if between the reading and the learning, another series were learned. The apparatus and conditions of the experiment were those for experiment *A* with the following changes: Two pieces of black cardboard were made to fit in a groove under the slit in the screen. One was a straight piece which was just long enough to cover the middle and one side syllable, letting the other side syllable show. This could be slipped to the right or the left, exposing the syllables of whichever side was desired. A second piece of cardboard had a square hole cut in the middle, so that when it was slipped into the groove, only the middle one

of the three series appeared. One or the other of these pieces of cardboard was kept before the slit all the time, so that only one syllable ever appeared to the subject at a time, and that a syllable of the series being read or "learned." The cardboards were manipulated by the observer. The procedure was as follows: One series was read a single time by the observer, the shutter was closed by the experimenter and the cardboard changed or shifted so that the series to be "learned" would show; the experimenter lowered the shutter at the end of the one intervening revolution, and the observer then began the reading of the series to be "learned." As before, ten minutes intervened for rest and introspections between the beginning of successive series. The programme in outline is as follows,—

Read *a* once, and wait 1 revolution of the drum
"Learn" *b*, i. e., read *b* 12 times
" *a* " " *a* " " beginning 10 min. after beginning *b*
" *g* " " *g* " " " " " " " *a*
" *h* " " *h* " " " " " " " *g*
Read *i* beginning 10 min. after learning *h;* wait 1 turn of the drum
"Learn" *j*, i. e., read *j* 12 times
" *i*, " " *i* " " beginning 10 min. after beginning *j*.

The *a* series was always written at the left of one strip, the *b* series in the middle, the *g* series in the middle and *h* on the right of a second strip, the *i* and *j* series on the left and right, respectively, of a third strip of paper. No extra series were used. The *g* and *h* series, which were learned without having been previously read were used as a check on the results of the other four series.

The experiment extended from April 14 through April 24, omitting the intervening Sunday, making ten days of experimental work. Twelve repetitions were used for each series except for *S*, for whom the number of repetitions was reduced to ten on the seventh day, because he was frequently getting more than half the syllables right.

The results are given in the following table:

TABLE III

Series	b	(P.E.)	a	(P.E.)	g	(P.E.)	h	(P.E.)	j	(P.E.)	i	(P.E.)
Obs. S	4.7	.36	4.6	.19	4.5	.26	3.7	.26	3.7	.26	4.7	.24
	4.7	.36	4.3	.27	4.1	.15	3.5	.23	3.3	.23	4.5	.31
E	3.7	.15	3.2	.24	3.3	.30	3.4	.17	3.2	.28	3.4	.32
	3.5	.23	3.0	.23	3.0	.17	3.1	.21	2.8	.28	3.3	.37

The second line of averages, reading across, are those for perfect syllables only.

If a single reading of the series before learning a second series has helped the first series when it was learned ten minutes later, the *a* series will be better than the *b* and the *i* than the *j*. But considering the large P. E. neither series for *E* is helped by its reading, nor the *a* series for *S*. But for the latter the *i* series shows a marked superiority to the *j* series. This is in part explained by the introspective accounts which show that this series was favored by slightly better conditions, as ease of syllables and attention paid while learning the series. The superiority of the *g* over the *h* series is also to be explained in the same way.

It was thought, after obtaining these results that perhaps the *a* series did not show an increased average because the average of the *b* series was kept high by the fact that it was the first series and, for that reason, learned with special energy; also, the *i* series might have been favored above the *j* series because of a renewed impulse to succeed which often comes when one is almost at the end of his task. Therefore, a third variation was tried as follows:

Experiment C. The two indifferent series, *g* and *h*, were made respectively the first and last series learned. The places of the *a* and *b* series on the drum were interchanged, and also those of the *i* and *j* series to avoid any effects which position at the right or left of the paper might have had. The principle of the experiment is, however, precisely that of Experiment B, viz., one series was read, a second learned, and then the series which had been read was learned. The time intervals are those of Experiment B. The scheme in outline is:

Learn *g*	Read *j*
Read *b*	Learn *i*
Learn *a*	Learn *j*
Learn *b*	Learn *h*

In order to get as exact information as possible as to the relative ease of the series compared, account was taken of all the "mnemonics" and of slight associative aids. After giving the syllables associated with the "Treffer" syllables, the observer was shown the series again and asked to give with that help any "mnemonics" or other aid he had had in learning the series, and these the experimenter noted down.

The experiment extended from April 28 through May 10, omitting Sunday, May 2, and covered ten experimental days. The results are given in Table IV. The second line of averages for each subject takes account of perfect syllables only.

TABLE IV

Series	g	(P.E.)	a	(P.E.)	b	(P.E.)	i	(P.E.)	j	(P.E.)	h	(P.E.)
Obs. S	4.7	.17	4.5	.22	3.9	.23	3.4	.30	4.2	.33	3.7	.20
	4.2	.14	4.2	.23	3.6	.25	3.1	.32	3.7	.26	3.5	.25
E	4.2	.21	4.3	.24	4.1	.30	2.9	.40	4.0	.24	3.7	.31
	4.1	.21	4.1	.26	3.9	.32	2.6	.42	3.7	.23	3.5	.31

If reading the series were a help, the *b* series would show better results than the *a* series, and the *j* than the *i*, but this is not the case except for the *i* and *j* series when learned by *E*, where, despite the large P. E., the *j* series shows a real superiority. This is due to the fact that on two of the experimental days the *j* series was extraordinarily better than the *i*, and if these two days are left out of consideration the difference is too slight to be of importance. As experiments *B* and *C* are really two divisions of the same experiment, there being no difference in character, we may average the results of the two, which will give the results for twenty days experimentation. Series 1 and 3 are those learned without previous reading, and 2 and 4 those learned with one reading before an intervening series was learned. They are contained in the table following; only the averages including partially correct syllables are given.

TABLE V

Series	1 (P. E.)	2 (P. E.)	3 (P. E.)	4 (P. E.)
Obs. S Av.				
Exper. *B*	4.7 .36	4.6 .19	3.7 .26	4.7 .24
" *C*	4.5 .22	3.9 .23	3.4 .30	4.2 .33
Av.	4.6 .29	4.3 .21	3.6 .28	4.5 .29
Observer E				
Exper. *B*	3.7 .15	3.2 .24	3.2 .17	3.4 .32
Exper. *C*	4.3 .24	4.1 .30	2.9 .40	4.0 .24
Av.	4.0 .20	3.7 .27	3.1 .29	3.7 .28

If the extra reading was of advantage, Series 2 should be better than series 1, and 4 than 3. This is indeed the case with series 4 for *S* and to a slighter degree for *E*, but for series 1 and 2 the required relation is exactly reversed. Unless one is willing to infer that the preliminary reading is a hindrance at the beginning of the day's session and a help at its close (for which there seems no obvious reason), one is forced to regard the result of the experiment as negative. Subjective conditions, such as better attention, will perhaps explain the difference.

In conclusion we may say, then, that the results of all our experiments with meaningless syllables were negative. The presence of a series on the side of a series learned did not cause this side series to show more facile learning than the series not so aided, at least to a degree discoverable by our method. Nor did actually reading the series before learning a series give clearly better results for this series when it was learned later.